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*Notified in
A.C.Is. for the
week ending
13th December,
1939*

Small Arms Training
Volume I, Pamphlet No. 7

·303-inch Machine Gun
Part III.—Fire Control

1939

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CONTENTS

DISTRIBUTION

TRAINING UNITS

GENERAL

Small Arms Training, Vol. I, Pamphlet No. 7, Part III, deals with the various methods of applying machine gun fire. It is written for officers and N.C.Os. whose duty it will be to direct and control fire, but before studying it they should be thoroughly conversant with Small Arms Training, Vol. I, Pamphlets No. 1, Sec. 2 (Theory of Small Arms Fire) and No. 2 (Application of Fire). A very elementary knowledge of mathematics will assist the reader in grasping the methods of fire control quickly.

DEFINITIONS

(See also S.A.T., Vol. I, Pamphlet No. 7, Part II)

Angle of distribution.—The angle between adjacent lines of fire opened up to divide a target wider than the gun frontage into equal parts, the flank guns being laid on the flanks of the target.

Angle of sight.—The angle contained between the line of sight and the horizontal plane. The angle is said to be positive (+) when the target is above the horizontal plane through the gun position (Fig. 4) and negative (−) when the target is below it (Fig. 5).
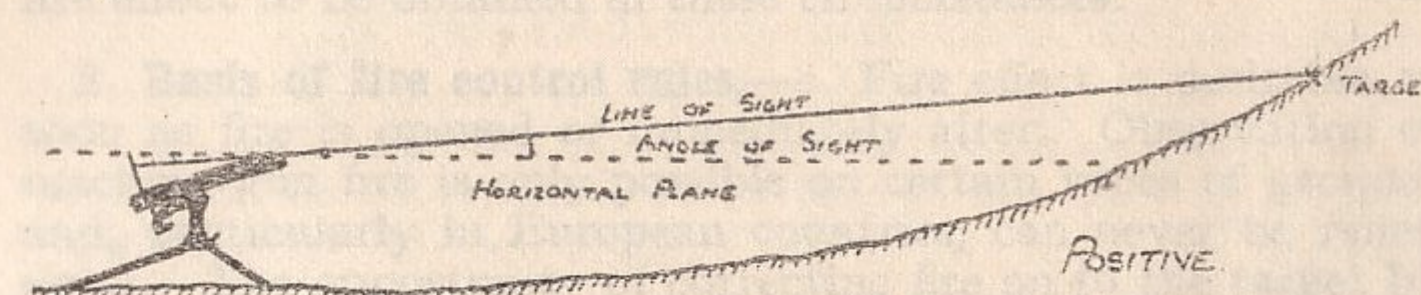

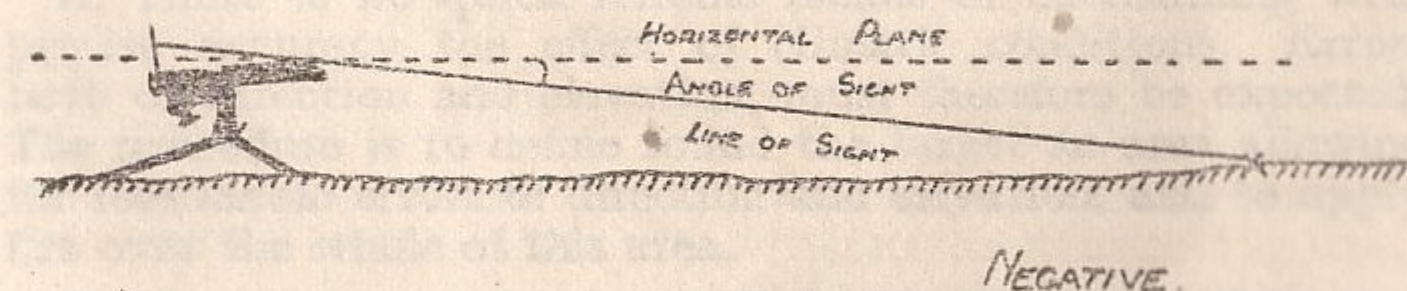Fig. 4.

Fig. 5.

Crest clearance angle.—The angle by which the axis of the barrel must be raised above the line of sight to the crest to ensure that all the bullets clear the crest.

Distribution.—The opening out of parallel lines of fire.

Flanking fire.—Fire applied from a flank across the front of a locality occupied by our own troops, or, if they are advancing, at an angle to their line of advance.

Fixed line.—A term denoting that measures have been taken for maintaining elevation and direction in darkness, smoke etc., so that fire will fall on a pre-arranged area of ground.

Line of fire.—The direction of the target from the gun.

Minimum clearance.—A term used to denote the minimum height of the centre bullet of the cone above the heads of our own troops for the latter to be safe.

Overhead fire.—Fire passing over the heads of our own troops.

Quadrant angle.—The angle which the axis of the barrel makes with the horizontal plane.

Safety angle for flanking fire.—The minimum lateral angle by which a line of fire must clear our own troops in order to ensure their safety.

Safety angle for overhead fire.—The minimum angle which must be included between the axis of the barrel and the line of sight to our own troops to ensure their safety under overhead fire.

Tangent angle.—The angle which the axis of the barrel makes with the line of sight.

SECTION 23.—GENERAL PRINCIPLES

1. Introduction.—The considerations which govern the method of applying machine gun fire are :—

  i. The best fire effect on the whole target.
  ii Economy of time and ammunition.
  iii. Simplicity and speed.
  iv. Safety of our own troops.

The factor of surprise as applied to fire cannot be over-estimated.

Fire control orders must be framed in such a way that all these requirements are met.

The system of fire control laid down in this pamphlet is worked out on the above basis and should be adhered to. Occasionally the situation may not permit the rules given to be carried out in their entirety. Common sense, and a knowledge of how the rules are arrived at will enable the best fire effect to be obtained in these circumstances.

2. Basis of fire control rules.—i. Fire effect is desirable as soon as fire is opened or immediately after. Observation of machine gun fire is only possible on certain types of ground, and, particularly in European countries, can never be relied upon. The opportunity of correcting fire on to the target by observation of strike will therefore seldom occur.

ii. There is no quick reliable means of determining with precise accuracy the effect of climatic conditions. Errors both of direction and elevation, must therefore be expected. The procedure is to define round the target an area allowing for reasonable errors of direction and elevation, and to apply fire over the whole of this area.

iii. The rules of fire control contained in the following sections are based on the assumption that insufficient observation of strike will be obtained to deduce the exact position of the beaten zones. Every endeavour, however, must be made to pick up strike of the bullets and to correct fire.

3. Direct or indirect fire.—i. The normal method of engaging a target at the shorter ranges will be by direct fire,

i.e. by laying on the target over the sights. The main asset of direct fire is its extreme flexibility, which enables a succession of targets over a wide arc to be engaged with facility.

The technical disadvantages of direct fire are the personal errors of Nos. 1, in laying, the difficulties of indicating and recognising the target, and the possible obscuration of the field of view.

ii. The machine gun is capable of firing indirect, *i.e.* the gun is laid on an auxiliary aiming mark, with the elevation required to hit the target, obtained and placed on the gun by instruments. Indirect fire is employed when it is impossible or inadvisable to occupy a direct fire position, or when shooting from a map.

The main technical advantage of indirect fire is that the necessity for indicating the target to a number of individuals is removed. The laying of the gun is mechanical, and its accuracy is not affected by light or distance.

The disadvantages are the necessity for additional measurements and calculations, and the difficulties of crest clearance owing to the flat trajectory.

iii. Conditions which obstruct the field of view (*e.g.* bad visibility, fog, smoke screens, etc.) often arise after a position is occupied. Consequently, when direct fire is to be employed, certain arrangements as for indirect fire, should be made as soon as time permits. The details of these arrangements can be found in Section drill—Direct fire (Sec. 17).

iv. The principles and details of fire control set down in this pamphlet apply both to direct and indirect fire. As the methods of fire, and details of fire discipline, are in many cases not the same, direct and indirect fire are treated separately in the remainder of this part.

SAFETY PRECAUTIONS

On all occasions when the gun and dummy cartridges are used for instructional purposes, the instructor will carry out the following safety precautions:—

i. **Inspect all locks to ensure that the striker does not protrude through the firing pin hole.**

ii. **Inspect all ammunition to ensure that all cartridges are dummies.**

Note.—When instruction is being given in mechanical subjects, D.P. stores if available will always be used.

LESSON 95.—ELEVATION

Instructor's Notes

Stores :—

Gun and tripod, dial sight, range table, blackboard.

First ensure that the class understand the forces which act upon the bullet (S. A. T., Vol. I, Pamphlet No. 1, Sec. 2).

Explain the tangent angle and demonstrate how it is applied to the gun by the tangent sight—show how whenever the gun is laid (direct or indirect) the two components of elevation are the tangent angle and the angle of sight.

Demonstrate elevation as applied to the gun with the dial sight (indirect fire) and finally explain the quadrant angle.

1. When firing direct, elevation is given to the machine gun by setting the tangent sight at the graduation corresponding to the range to the target and directing the line of sight on to the point of aim. This process sets the axis of the barrel
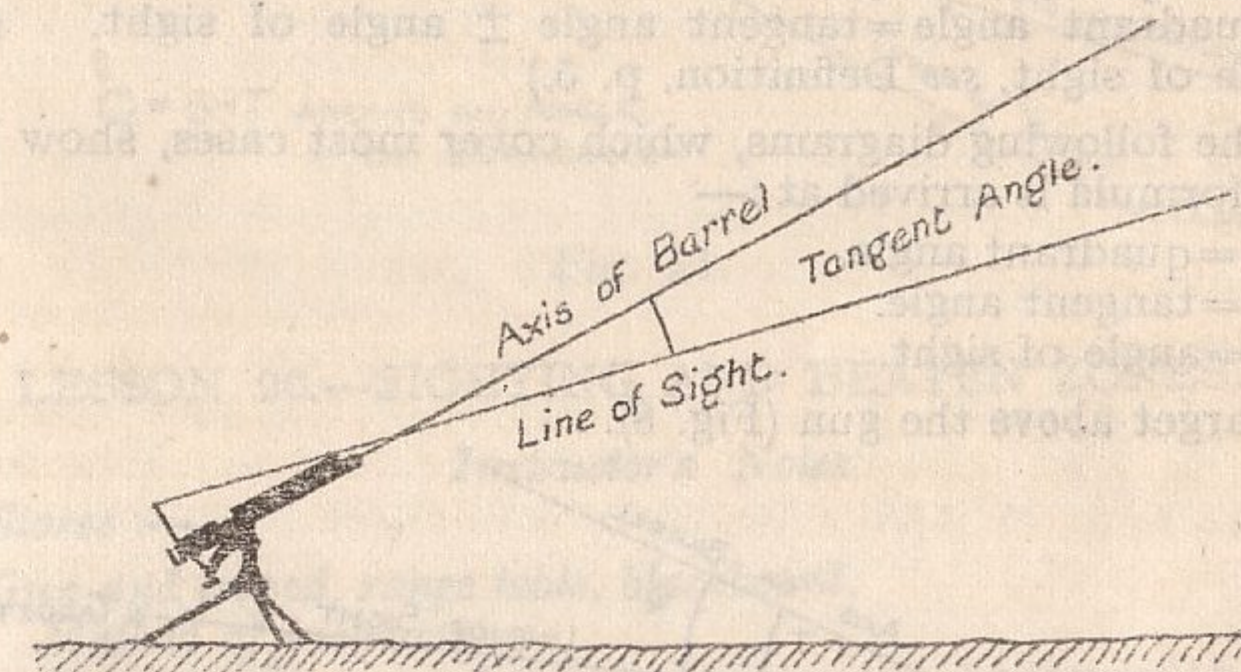
Fig. 6.

at an angle above the line of sight (Fig. 6). This is the angle of tangent elevation (tangent angle) for the range at which the tangent sight is set.* Tangent angles for all ranges have been determined and are laid down in the Range Table.

2. When firing indirect elevation or depression is placed on the gun by means of the dial sight in two components :—

i. The range (tangent angle) on the range drum.

ii. The angle of sight to the target on the angle of sight drum.

It may sometimes, however, be convenient to the fire controller to be able to express the angle of elevation given

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* Except where the line of sight is abnormally steep, *i.e.* in mountainous countries. This is explained in Lesson 96.

to a gun in relation to the horizontal. This angle is known as the quadrant angle, and is the angle between the axis of the barrel and the horizontal (Fig. 7).
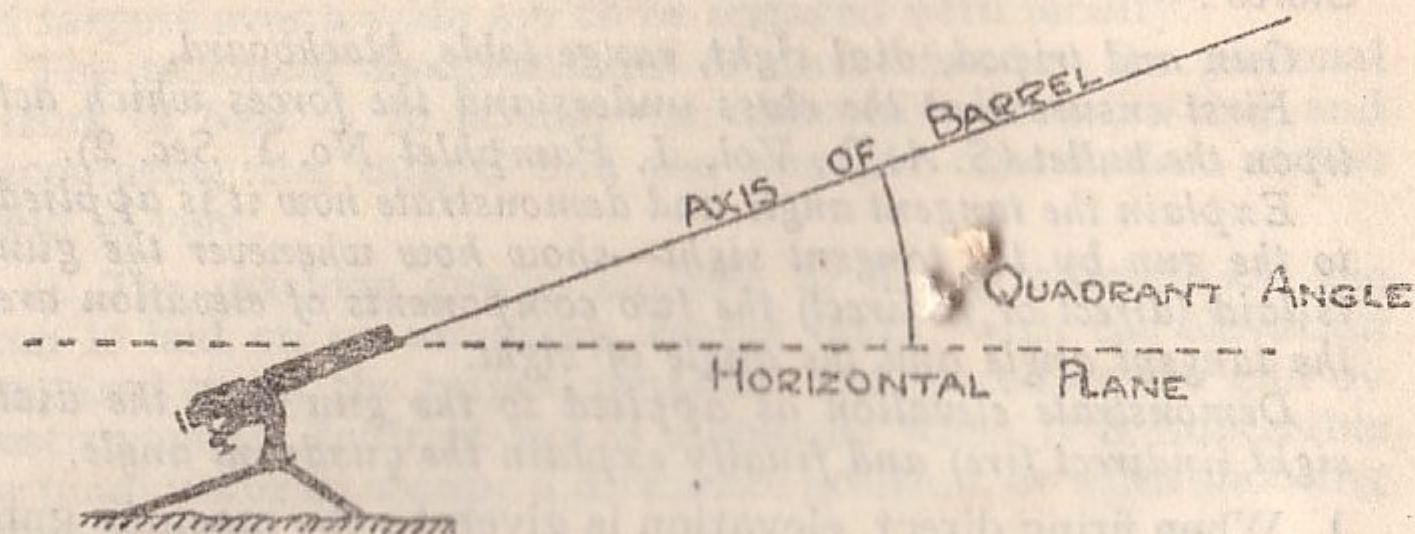
Fig. 7.

The quadrant angle is calculated from the formula :—

Quadrant angle = tangent angle ± angle of sight. (For angle of sight, *see* Definition, p. 5.)

The following diagrams, which cover most cases, show how the formula is arrived at :—

Q = quadrant angle.
T = tangent angle.
S = angle of sight.

Target **above** the gun (Fig. 8).

Q = T + S, and is an Angle of Elevation
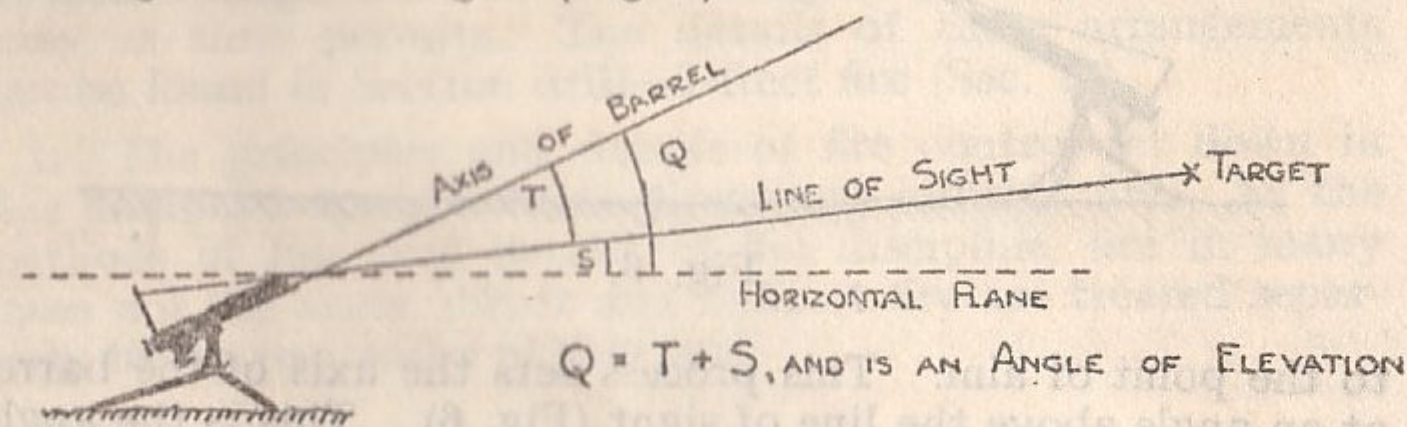
Fig. 8.

Target **level** with gun (Fig. 9).

The Angle of Sight is Zero, and Q = T
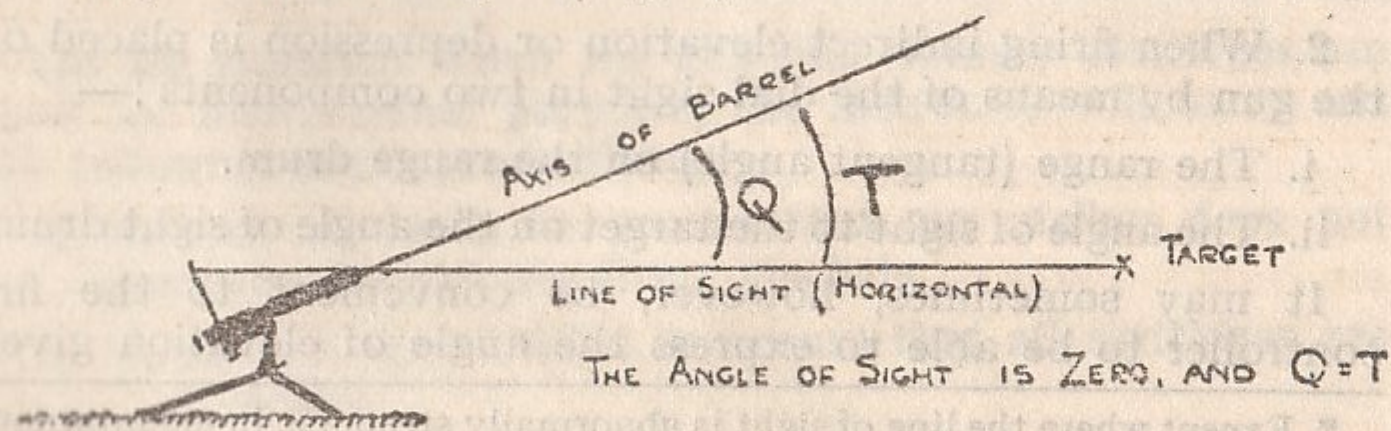
Fig. 9.

Target **below** gun (Fig. 10).

Q = T - S and is an Angle of Elevation
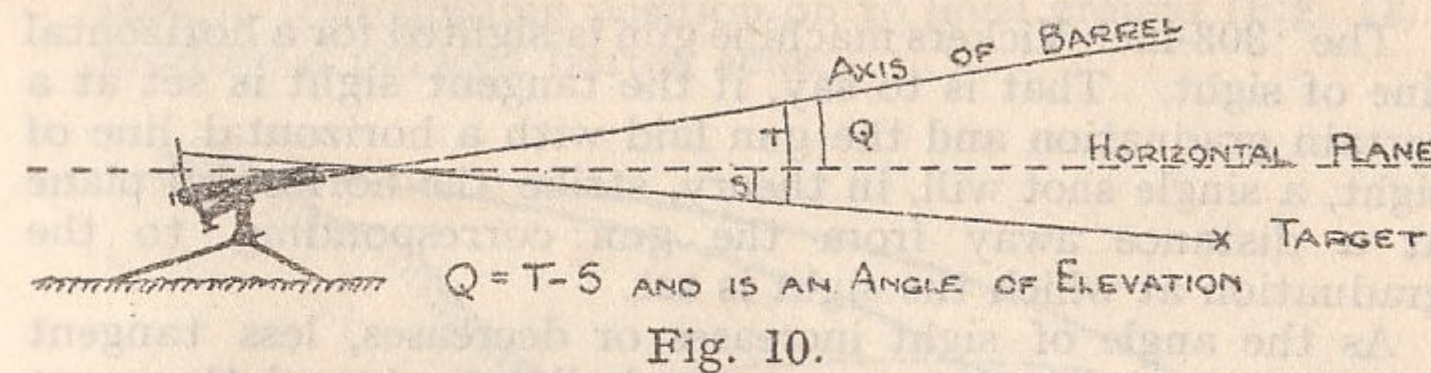
Fig. 10.

Target **far below** gun (Fig. 11).

Q = S - T and is an Angle of Depression
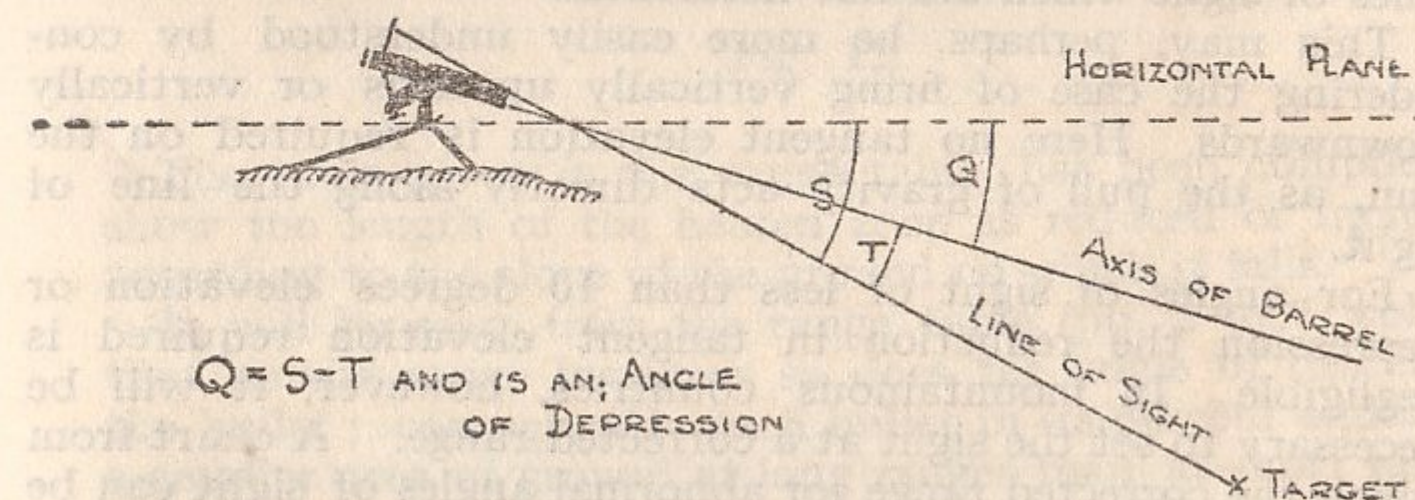
Fig. 11.

LESSON 96.—SIGHTING AND BEATEN ZONES.

Instructor's Notes

Stores :—

Gun and tripod, range table, blackboard.

Method of instruction.

Explain the normal (i.e. approximately horizontal) line of sight) and the abnormal in conjunction with the chart in the Range Table, 1939, page 17 and para. 2 below.

Explain the beaten zone and how it is affected by ground (range table, p. 14).

EXPLANATION

1. Sighting of machine guns.—

In common with other small arms, a mean graduation for each range has been adopted, and guns are carefully tested for accuracy before issue. In course of time wear to mountings and barrels, and irregularities in packing, may require individual gun corrections to be made when setting the tangent sight for a particular range.

On all occasions when the gun is firing ball ammunition and it is possible to determine the range with accuracy, the gun range should be noted, if possible corrected for the atmospheric conditions of the day, and recorded.

2. Effect of not having a horizontal line of sight.—

The ·303-inch Vickers machine gun is sighted for a horizontal line of sight. That is to say, if the tangent sight is set at a certain graduation and the gun laid with a horizontal line of sight, a single shot will, in theory, strike the horizontal plane at a distance away from the gun corresponding to the graduation at which the sight is set.

As the angle of sight increases or decreases, less tangent elevation is required to cause the bullet to travel the same distance, because the pull of gravity is not at right angles to lines of sight which are not horizontal.

This may, perhaps, be more easily understood by considering the case of firing vertically upwards or vertically downwards. Here no tangent elevation is required on the gun, as the pull of gravity acts directly along the line of sight.

For angles of sight of less than 10 degrees elevation or depression the reduction in tangent elevation required is negligible. In mountainous countries, however, it will be necessary to set the sight at a corrected range. A chart from which the corrected range for abnormal angles of sight can be obtained is given in the Range Table, 1939, p. 17.

3. Beaten zones.—

The beaten zone of the machine gun has similar characteristics to that obtained in collective rifle fire. The fixed mounting gives greater accuracy and closer grouping. The dimensions of the beaten zones for various ranges have been obtained by experiment, and are laid down in the range table. The rules contained in this pamphlet are based on these dimensions, which vary little for different guns and mountings, and hence can be taken as constant for each range.

As in collective rifle fire, the length of the beaten zone decreases as the range increases. Beyond 2,700 yards the machine gun beaten zone again begins to increase. This is due to minor differences in the velocity of individual bullets.

Its breadth increases up to extreme range.

The fact that it is narrow in comparison to its length calls for great accuracy in direction, and renders the gun peculiarly suited to engage from a flank targets with width and little depth.

If, however, the target has depth it may be advisable to engage it by frontal fire, so that the length of the beaten zone may be employed to cover the depth of the target as opposed to its width.

The effect of ground on the beaten zone of the machine gun is in general as shown in Pamphlet No. 1 for the rifle.

In addition, it should be remembered that plunging fire from a commanding position on to level ground (Fig. 12) will produce a reduced beaten zone.
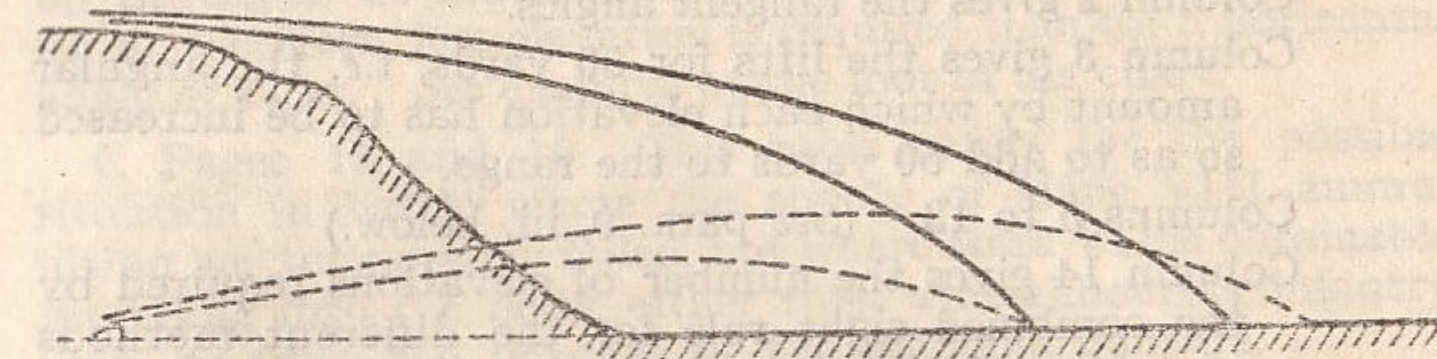
Fig. 12.

The table given in the range table, has been compiled to show the length of the beaten zone as reduced or increased according to the slope of the ground on which it falls.

It will be seen from the range table (pp. 2 to 7, col. 23) that as the range increases so does the angle of descent of the bullet ; consequently each bullet in its descent endangers a smaller area of ground at long ranges than at short ranges.

It follows that as the range, the error in determining the range (*see* lesson 97), the area of the beaten zone, and the angle of descent of the bullet increase, the destructive or neutralising effect of the fire of each machine gun becomes greatly reduced. To compensate for this, a larger number of machine guns should be employed on neutralising tasks at long ranges.

The greatest width of front which can be effectively engaged at any range is 50 yards per gun.

The length of bursts of machine guns will normally be about 25 rounds at all ranges, except that on fixed line tasks or when engaging moving targets, the bursts should be increased to about 50 rounds.

LESSON 97.—RANGE TABLE AND CLIMATIC INFLUENCES

Instructor's Notes

Stores :—

Range table, blackboard.

Those parts of the range table which are described in this lesson should be explained, and simple exercises in them should be set, until the class is thoroughly familiar with them.

1. Pages 2 to 7.

 Columns 1 and 26 give the ranges in 50's from 50 to 4,500 yards.

 Column 2 gives the tangent angles.

 Column 3 gives the lifts for 50 yards, *i.e.* the angular amount by which each elevation has to be increased so as to add 50 yards to the range.

 Columns 5 to 13. (*See* para. 9, iii, below.)

 Column 14 gives the number of elevations required by the combined sight rule for the different methods of determining the range. (*See* Lesson 98.)

 Columns 19 and 20 deal with the height of the cone.

 Column 20 gives its total height, and column 19 gives the angle subtended at the gun by half its height.

 Column 21 gives the width and length of the beaten zone. The figures given are for 90 per cent. of the total shots fired. The stray shots, which produce little fire effect are therefore not included. The length of beaten zone is that along the line of sight.

 Column 22 gives the time of flight at each range.

 Column 23 gives the slope of descent of the bullets compared with the line of sight. This figure enables a fire controller to calculate whether his fire can be brought to bear on reverse slopes.

 Columns 24 and 25. (*See* para. 9, ii, below.)

 Columns 4 and 15 to 18 deal with crest clearance and safety which will be learnt later.

2. Pages 9 to 13 deal with the displacement method of indirect fire which is described in Lesson 109.

3. Pages 14 and 15 give the foreshortening effect of a forward slope on the length of the beaten zone, and the lengthening effect of a reverse slope.

 The gaps in the bottom left-hand corner of the table are due to the fact that at those figures, the reverse slope is steeper than the angle of descent of the bullet, so that such slopes are " dead ground " when engaged at those ranges.

4. Page 16 gives the formula to determine the angle of sight (Lesson 114) and the allowance for moving targets (Lesson 105).

5. Page 17. The machine gun is sighted for a horizontal angle of sight, and in this sighting is sufficiently accurate for all angles of sight between plus 10° and minus 10°.

If the angle of sight exceeds 10°, allowance must be made in accordance with the chart. If it be imagined that a target is being engaged immediately above or below the gun, *i.e.* at an angle of sight of 90°, clearly no tangent angle is required on the sight, no matter what the range. At steep angles of sight, therefore, less elevation is required than for a horizontal angle of sight. *See* example at the foot of the chart.

6. Pages 18 and 19. This table caters for the possible situation in battle where the supply of Mark VIII ammunition has temporarily failed, but where Mark VII is obtainable for filling into the belts, either from a neighbouring infantry unit, or from the pouches of the machine gunners.

 Owing to the differences in trajectory of the two kinds of ammunition, the reading on the tangent sight for Mark VIII is not correct for Mark VII. In columns 2 and 8 are given the readings to be put on the sights when engaging targets at ranges shown in columns 1 and 7.

7. Graph for calculating quadrant elevation and clearances (The Q.A. Graph).

 This graph is formed by plotting the path of the centre bullet for quadrant angles, increasing by 15' increments, from depression 2° to elevation 17° 30'.

 The red horizontal line marked "O" represents the horizontal line through the gun position. The other red horizontal line gives heights in hundreds of metres above or below the gun position. The intermediate black dotted lines give heights in tens of metres. The equivalent to heights in feet are given down the right edge of the graph.

 The vertical lines give the range from the target in hundreds yards intervals, the multiples of 1,000 being in red.

 The chief use of the graph is to determine the Q.A. for targets at any height above or below the gun.

For example :—

  Range to target (Rangefinder) .. 1,900.
  Height of target above gun .. .. 70 metres.

Find the point where the horizontal for plus 70 metres cuts the vertical line for 1,900 yards.

Note the curve which passes through this point. It is the curve for elevation 5°15'. (The curves for degrees are in red, those for 30' are in thick black, those for 15' and 45' in thin black.)

Elevation 5°15' is therefore the Q.A. required.

The graph can also be used in connection with crest clearance and the overhead safety of our own troops in cases where the

distance of the crest or own troops above or below the gun is found as a height and not as an angle of sight (*e.g.* map shoot). The use of the graph for these purposes is dealt with under the lessons concerned.

8. V.I. Graph.

The commonest uses of the V.I. graph are :—

i. Knowing the range, to determine the distance or height subtended by a certain angle.

ii. Knowing the range, to determine the angle subtended by a certain distance or height.

In Fig. 13, if G is the gun, and GA the range, then AB is the distance subtended by AGB at the range GA, and A_1B_1 is the distance subtended by the angle AGB at the range GA_1.

Similarly, the angle AGB is said to subtend AB and A_1B_1 at the ranges GA and GA_1 respectively.
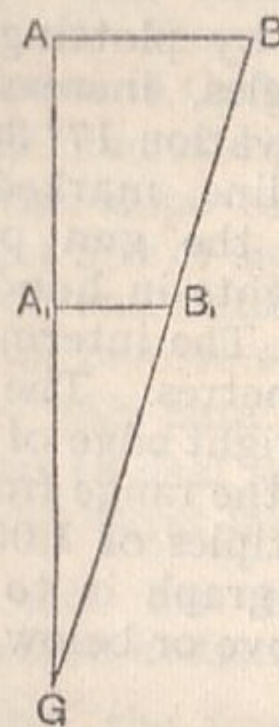
Fig. 13.

Example :—

Angles AGB equals 4° 10′.

Range GA equals 3,300 yards.

What is the length of AB ?

Find the point where the horizontal line for 3,300 yards meets the diagonal line for 4° 10′.

Follow the vertical line through this point down to the scale at the bottom of the graph, and the figure gives the length of AB. It is 240 yards.

9. Climatic influences.—

i. The following are the normal conditions for the sighting of small arms :—

Barometric pressure. 30 inches. (Mean sea level.)
Temperature. 60 deg. Fahrenheit.
Still air.
A horizontal line of sight.

ii. Barometer and temperature.

If the barometer falls below 30 inches, less elevation than is normally required for the distance will be necessary, as the atmosphere being less dense offers less resistance to the bullet. It should be noted that the barometer will fall 1 inch for every 1,000 feet above mean sea level.   If the barometer rises above 30 inches, more elevation is required, as the air is denser.

The bullet meets with less resistance in hot weather, when the temperature is high and the air less dense ; and greater resistance in cold weather, when the temperature is low.   In the former case, therefore, less elevation is required, and in the latter more.

Allowances for barometer and temperature variations are normally small, and are not usually necessary except at great heights or under conditions of extreme heat or cold.

Allowances for 1 inch rise or fall of barometer and 10° rise or fall in temperature will be found opposite each range in cols. 24 and 25 of pages 2 to 7 of the range table. It should be noted that for a *fall* in barometer, and a *rise* in temperature the allowance to be made is subtracted and vice versa.

iii. Wind.

Winds blowing directly along the line of fire from front to rear will affect the elevation, but here again unless the wind is very strong and the range long, the allowance required is small.

Winds blowing directly at right angles to the line of fire will affect direction, and have considerable effect on the bullet, particularly at long ranges.

Winds blowing from a direction oblique to the line of fire will affect both direction and elevation.

Although where speed is essential it may be necessary to estimate in taps the lateral allowance to be made for a side wind, recourse should be had to the wind table in the range table, when time permits.

Having estimated the strength and direction of the wind, the allowance required may be obtained from the range table on pages 2 to 7, columns 5 to 13.

An explanation of the use of the wind table is on page 8 of the range table.

10. The meteor telegram.—

In order to make accurate allowances for climatic influences, meteor telegrams are published periodically in war. They are primarily intended for artillery units, but it may be possible for M.G. units to arrange to be sent copies, or to obtain the necessary information from neighbouring artillery units. An example with explanatory notes is shown :—

FROM			Ground in Text	
Originator's number 14		Date 22	In reply to number	
Bar	3060	0539	16223	1037
19225	1535	21230	2033	23231
2530	25228	3030	26225	3530
28220				
Time of origin 1400		T.O.R.		

i. "Bar 3060" is the height of the barometer in inches, to two places of decimals, at mean sea-level (M.S.L.). For the purpose of applying corrections this figure must be corrected for the height of the gun position. The rules for this are : For every metre rise deduct 0·003 inch, or for every foot rise deduct 0·001 inch, from the mean sea-level reading.

ii. The first two figures in each four-figure group are the time of flight.

iii. The last two figures in each four-figure group give the air temperature in degrees Fahrenheit.

iv. Each five-figure group relates to the preceding group of four figures.

v. The first two figures in each five-figure group give the velocity of the equivalent constant wind in feet per second. To convert feet per second into miles per hour, multiply by two and divide by three. Thus 30 feet per second equals 30 multiplied by two divided by 3 = 20 m.p.h.

vi. The last three figures in each five-figure group give the true bearing from which the wind is blowing. This true bearing must be compared with the true bearing of the line of fire and converted to clock ray before the wind table is used.

vii. The groups always consist of the number of figures

shown, 0's being prefixed if necessary. Thus, 07004 would signify a 7 f.s. wind from a bearing of 4 degrees.

viii. Example :—

Range to target	2,900 yards.
Height of gun position above mean sea level	200 metres.
True bearing of line of fire	345°

(a) Barometer.

From telegram, reading at mean sea level	30·60 inches.
For altitude, subtract 200 × ·003	·60 inches.
	30.00 inches.

This is normal, so no correction for barometer is needed.

(b) Temperature.

Time of flight for 2,900 yards is 9·38 (say 10) secs.

From telegram, air temperature for a 10 sec. time of flight is	37° F.
Normal is	60° F.
Difference is	23° F.
Allowance for 10° F. at 2,900 is.. ..	9′.

Therefore extra elevation required for temperature is 9 × 2·3 or say plus 20′.

(c) Wind.

From telegram, for a 10 sec. time of flight wind is 19 feet per sec. from 225° true.

19 feet per sec. = 19 × 2 ÷ 3 = say 13 m.p.h.

Angle between wind and line of fire is 345 − 225 = 120°. So wind is 8 o'clock.

A 10 m.p.h. wind at 2,900 yards requires a correction in elevation of minus 6′.

Therefore a 13 m.p.h. wind requires minus 6 × 1·3 = − 8′.

A 10 m.p.h. wind at 2,900 requires a correction for direction of Left 30′.

Therefore a 13 m.p.h. wind requires Left 30 × 1·3 or Left 39′.

Climatic corrections are therefore :—

Elevation plus 20 − 8′	or plus 10′ to the	
Direction Left 40′.	nearest 5′.	

LESSON 98.—RANGE OR RANGES

Instructor's Notes

Stores as for Lesson 97.

Explain :—

1. Errors in elevation may be caused by :—

    i. Inaccuracies in determining the range.

    ii. Incorrect allowances for climatic variations.

2. The range may be determined by :—

    i. Range-finding instrument—the most accurate method for ranges up to 2,000 yards.

    ii. Measurement on a map of not less scale than 1/25,000. For ranges over 2,000 yards this method is, likely to be the most accurate provided that the map is in good condition and the gun position and target can be accurately located.

    iii. Key-ranging.—That is by estimating from ranges taken by either of the above methods. This method is reasonably accurate up to 2,000 yards, but beyond that is of little practical value.

3. For fire effect to be obtained on a point target, it is necessary to ensure that the beaten zones cover all points at which that target may be having regard to the error in determining the range.

For example, assuming the error in determining the range to be 10 per cent., and the range to have been given as 700 yards, the target may lie anywhere on the line of sight between 630 and 770 yards. At 700 yards, the length of the beaten zone along the line of sight is 195 yards, and it therefore extends from 602½ yards to 797½ yards range.

Thus, in this example, it more than covers all points where the target may lie.

In this example, it would be sufficient to fire with the gun or guns at one elevation (700) only, but at the longer ranges, when errors in determining the range increase and (up to 2,650) beaten zones decrease, it becomes necessary to fire on more than one elevation.

A "combined sight" table is therefore necessary so that the fire controllers shall know how many elevations are needed at different ranges. This table is included in the range

tables, but for ranges up to 2,000 it is simple and should be learnt by heart :—

COMBINED SIGHT RULE

RANGE	No. of elevations required	
	Rangefinder or map	Key Ranging
Up to 800 yards (inclusive) ..	One	One
Above 800 and up to 1,400 ..	One	Three
Above 1,400 and up to 2,000 ..	Three	Five

4. Fire will be opened with all guns at the range obtained, plus or minus any allowance for head or rear winds. This procedure ensures that the best use is made of any observation of strike of the bullets.

If three elevations are required by the combined sight rule, they will be the opening elevation, and the elevations 50 yards less and 50 yards more.

If five elevations are required, they will include also the ranges 100 yards above and 100 yards below the opening range.

SECTION 24.—DIRECT FIRE

1. The direct fire unit is the section, because :—

    i. Two guns are required to give the necessary volume at the most usual machine gun ranges.

    ii. At the longer ranges, two guns are required to ensure hitting the target without undue delay.

    iii. In case of stoppage of one gun, sustained fire can be maintained by the other.

    iv. It can be easily concealed and is not too vulnerable.

2. The requirements of fire control necessitate the two guns being under the command of a fire controller who is supplied with a range-taker to enable him to determine the range.

3. In order to avoid casualties the two guns of a section in action should be as far apart as possible, provided that the section commander is able to control both guns by voice.

4. With reference to para. 1, above, at distances beyond 1,400 yards, the volume of fire produced by a section cannot always be relied on to give results proportionate to the expenditure of ammunition, and the fire of two or more sections may have to be directed on to the same target from their respective positions.

LESSON 99.—FIRE ORDERS—DIRECT

Instructor's Notes

Stores :—

    Two guns and tripods, two directors, range tables, slide rules, landscape target, blackboard.

    This lesson should be carried out indoors with a blackboard and landscape target initially in the form of a lecture.

1. Explain that the following is the procedure for engaging a target by a direct fire unit.

    i. The fire controller, by means of a fire order, gives an elevation and indicates a point of aim on the target for each gun.

    ii. Each firer sets his tangent sight at the elevation ordered, and by tapping the gun, and the use of the elevating handwheel, directs the line of sight on to the point indicated for the gun. Thus the gun is laid initially for both elevation and direction.

2. Fire orders are given in a sequence, laid down in para. 3, below, and must not be departed from.

Rigid adherence to the sequence will ensure that errors and omissions are detected immediately, and, further, that the personnel, knowing what to expect, will act more quickly.

The orders must be given loudly and clearly, the fire controller facing towards the guns.

He must make up his mind what is the correct order to give before embarking on it. Long and unnecessary pauses during which he is coming to a decision as to the next part of the order, can only result in inaccuracies and slovenly drill.

The recipients must have time to act on one portion of the order before another is given.

3. The sequence of a direct fire order is :—

    i. Range or ranges.

    ii. Indication of the target.

    iii. Method of fire.

    iv. Side wind allowance.

    v. Rate of fire (if required).

    vi. Order to fire.

When giving out the order, pauses should be made as under, until it is seen that the gun numbers are ready for the next part of the order.

After the range .. .. To allow time to set the sights.

At various stages during the indication. Time must be given for points to be recognized. When degree methods of indication are used, a pause must be made to enable the angles to be measured.

After method of fire .. To enable the guns to be laid.

After wind, if any .. To allow of picking up a gun aiming mark.

4. **Range or ranges.**—

    i. Ranges, when ordered to the guns, will be given to the nearest fifty yards, and according to the following examples :—

        700—Seven hundred.

        1,000—Ten hundred.

        1,400—Fourteen hundred.

        1,450—Fourteen fifty.

        2,000—Twenty hundred.

        2,300—Twenty-three hundred.

        2,350—Twenty-three fifty.

    ii. For the first target the section commander will usually obtain the range from the range-taker, but where the situation

demands it, he should not hesitate to estimate the range. For subsequent targets, to save time, ranges are taken, or estimated, from the range card.

iii. If one range is ordered to the two guns the range will be preceded by the word "**all**" *e.g.* "**all—twelve hundred.**"

If two elevations are necessary, they will be given in the form :—

"**No. 1—Sixteen fifty.**"
"**No. 2—Seventeen fifty.**"

iv. If the wind is sufficiently high to warrant a correction for elevation, the allowance required will be calculated in yards (Lesson 97). The range will be corrected before being given out.

5. Indication.—

i. The section commander will indicate the target as laid down in Lessons 62 and 63. It should be noted that when switching from one target to another the last target is often the best aid in indication.

ii. When the dial or handwheel method of indication is used, an additional tap right and left of the target should be included in the method of fire to allow for possible errors.

6. Method of fire.—

i. (*a*) Order "**right and left . . . taps.**"

Both guns are laid on the centre of the target.

No. 1 gun taps to the left first and No. 2 to the right.

(*b*) Order "**traversing.**"

No. 1 gun is laid on the right end and No. 2 on the left end of the target.

NOTE.—In engaging an oblique target, this order to traverse will be preceded by "**No. 1 right half—No. 2 left half.**"

On completion of the "method of fire" order the section commander will order "**lay.**"

7. Side Wind.—

The section commander will either estimate the side wind required or calculate it to the nearest tap (Lesson 97). It will be ordered to the guns in the following form :—

"**Wind—right (or left . . . taps).**"

Nos. 1 tap their guns across by the number of taps ordered, pick up a gun aiming mark, and inform Nos. 2 when ready.

If the allowance required is 1° or more, it should be ordered in degrees. Nos. 1 by means of a hand angle pick up a gun aiming mark.

If no correction is necessary, this heading is omitted from the order.

8. Rates of fire.—

If no order is given, normal is implied.

If it is desired to fire "Rapid," the order will be given after the allowance for wind, if any.

9. The order to fire.—

This will normally be given by the fire controller ordering "fire." If more convenient he may signal "fire." (*See* Sec. 13, Signals.)

Attention is called to Lesson 96—Length of bursts.

10. The following orders may be given during a shoot :—

i. "**Stop.**"

This order is normally given by signal, the arm being waved horizontally to and fro.

ii. **Ranging corrections.**

(*a*) *Direction.*

The section commander converts the necessary deflection into taps, which he orders to one or both guns as required. Nos. 1 pick up a gun aiming mark in the new line.

Examples :—

All— . . . Right two taps.
No. 1— . . . Left three taps.

(*b*) *Elevation.*

The section commander decides on the correction, and either gives out a new range or orders "**up**" or "**down**" by the amount required.

Examples :—

"**All—Fourteen hundred.**"
"**All—Up two hundred.**"
"**No. 2—Up one hundred.**"
"**All—Down fifty.**"
"**All—Up 20 minutes.**"

(Corrections must be in minutes after the handwheel method of indication.)

In applying the combined sight rule, to cases where the two guns of a section are to have different elevations, the lower elevations will be given to No. 1 gun.

iii. "**Go on.**"

This order may be given verbally or by making the signal to fire.

11. Practise squad in open country.

LESSON 100.—METHODS OF FIRE

Instructor's Notes

Stores :—

Blackboard, landscape target.
The subject matter will be given in the form of a lecture.

1. Explain.—

Types of targets which machine guns will be required to engage are classified as :—

   i. Point targets (Lesson 101).

   ii. Targets with width (horizontal or oblique) having the same range to each end. (Lesson 102.)

   iii. Oblique targets having a different range to each end. (Lesson 103.)

   iv. Targets with depth. (Lesson 104.)

   v. Area targets. (Lesson 104.)

   vi. Moving targets. (Lesson 105.)

2. The firer is taught the required strength of tap to displace the line of sight by 15', this being the amount which it is calculated will cause successive beaten zones to overlap slightly. This tap is called the "regulation 15' tap."

3. Errors in direction may be caused by :—
   i. Wrong estimation of wind.
   ii. Slight inaccuracies of aim, wear in the mounting, etc.

As these errors may act either way, it will be necessary to engage an additional width on either side of the target. Lateral erros will not normally be great, but the beaten zone is narrow and so does not give much help in overcoming them.

The error increases in proportion to the range, and therefore a greater width will require to be engaged at long ranges than at short.

LESSON 101.—POINT TARGETS.

Instructor's Notes

Stores :—

Blackboard, landscape target, field glasses, spotlight apparatus.

1. Explain that errors in direction are overcome by the application of the following rule :—

Up to 800 yards inclusive.—The error should be covered by the width of the beaten zone.
Above 800 yards.—One tap right and left.
Above 1,400 yards.—Two taps right and left.

2. Illustrate a fire unit engaging a point target at a range of 1,600 yards obtained by range-finder, requiring two taps right and left. (Fig. 14.)
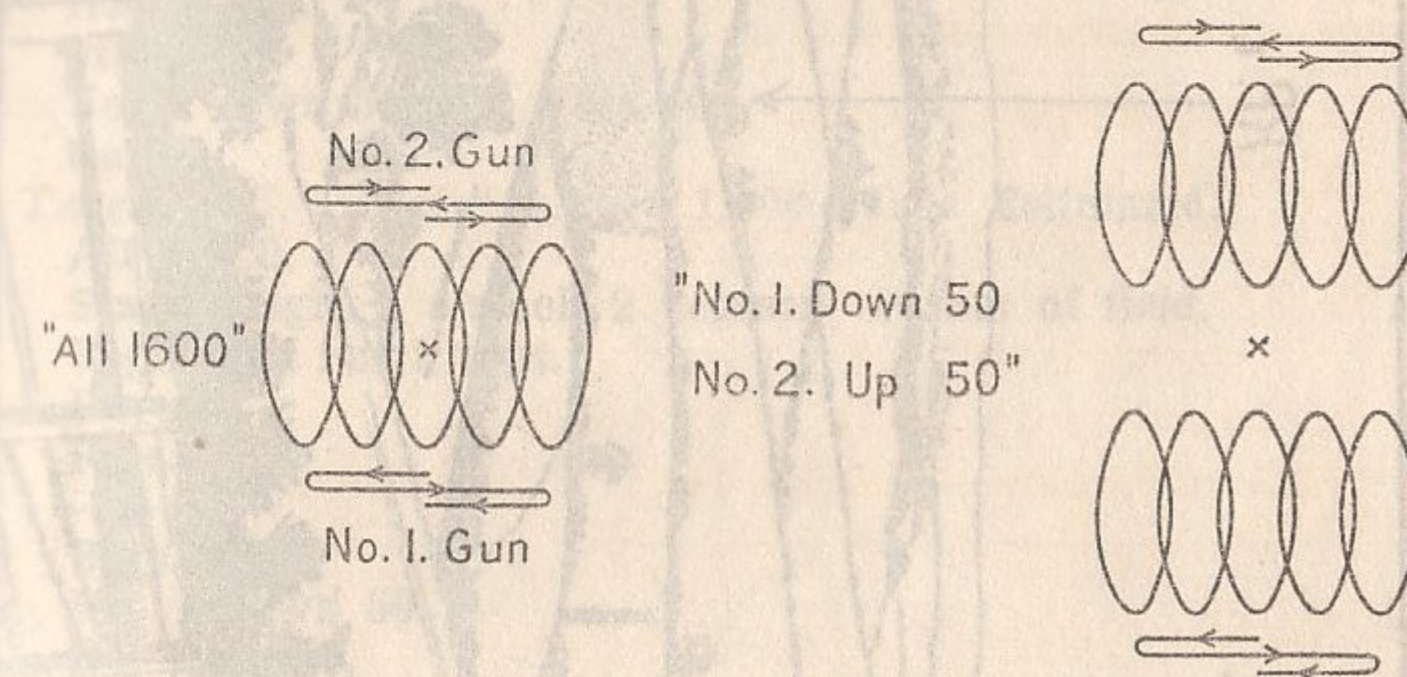
Fig. 14.—Tapping right and left.

3. Explain and show examples that if the point of aim is indefinite (including an indication with the aid of dials or handwheels), an extra tap right and left must be given.

4. Explain in engaging *point targets*, the fire controller will indicate the centre of the target as the point of aim for both guns. Targets with a little width will also be engaged in this way, the number of taps required according to rule above being increased to cover the extra width. As a guide, if the number of taps right and left to be given exceeds three, the target will be treated as a target with width.

5. With the aid of the "Apparatus, Weapon Training, Spotlight, Mk. II," practice the engagement of point targets.

6. Examples of fire orders to engage point targets.
The following reference points have been selected on the landscape as shown in Plate 23.

   i. Haystacks (R.P.1)—left bottom corner known as **stack**.

   ii. Two poplars (R.P.2)—left poplar known as **poplar**.

PLATE 23

D.
A.
RP. 1.
C.
B.
RP. 2.
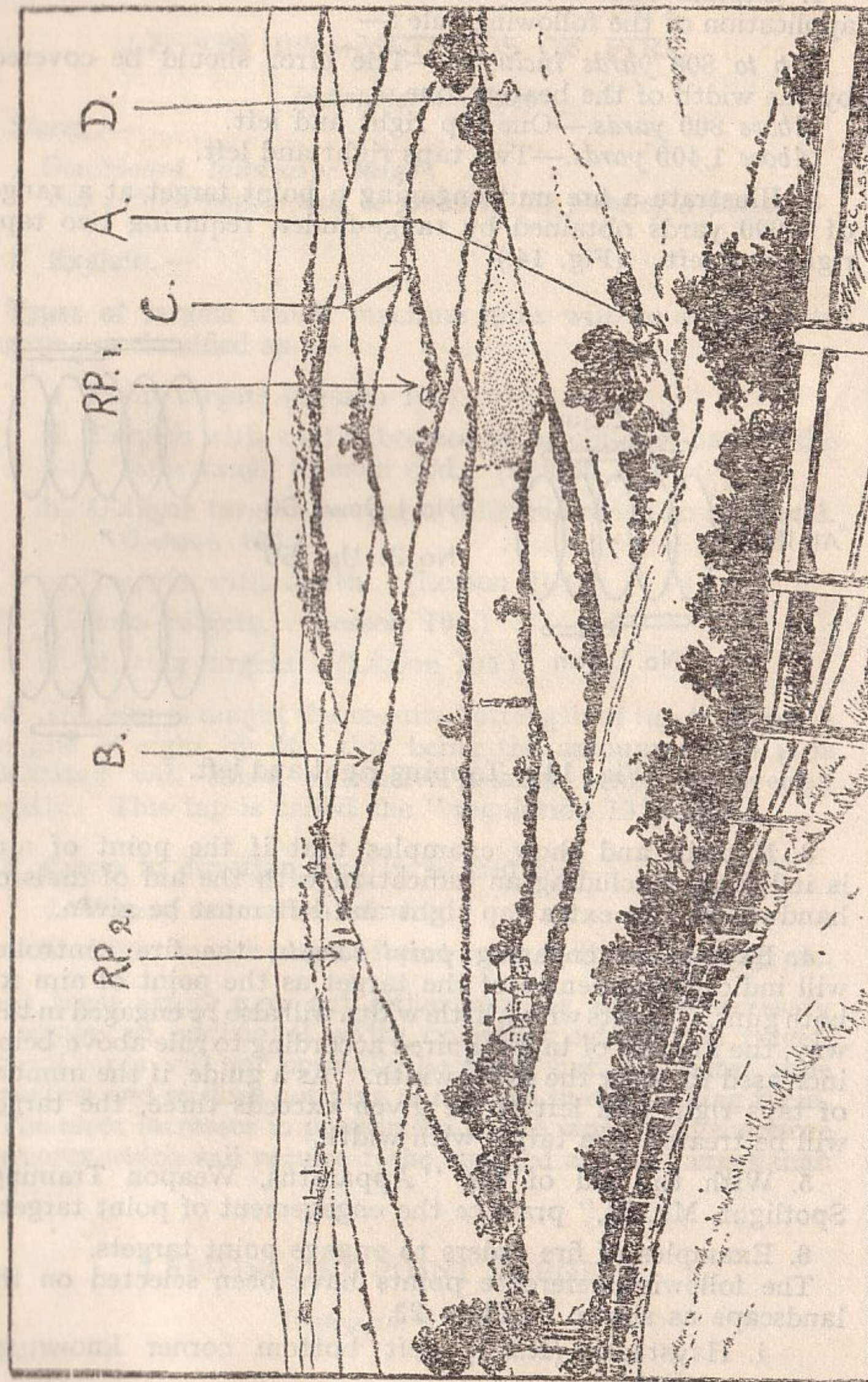
Target "A." Point target 750 yards.
All 750.
Right of arc—pond—near side—large tree.
Lay.
Rapid fire.
Target "B." Point target 1,600 yards (range-finder).
All 1,600.
Poplar—right 3 o'clock 3 degrees—bush.
Right and left 2 taps.
Lay.
Wind—right—1 tap.
Rapid fire.
Stop.
No. 1 down 50, No. 2 up 50.
Go on.
Target "C." Point target 1,600 yards **Estimated**.
All 1,600.
Stack—right 2 o'clock 2 degrees—corner of field.
Right and left 2 taps.
Lay.
Fire.

Stop.
No. 1 down 50.
No. 2 up 50.
Go on.

Stop.
No. 1 down 50.
No. 2 up 50.
Go on.
Target "D." Point target 1,150 yards (range-finder)
45' wide.
All 1,150.
Right of arc—4 large trees.
Right and left 3 taps.
Lay.
Wind—left 1 tap.
Rapid fire.

LESSON 102.—TARGETS WITH WIDTH HAVING
THE SAME RANGE TO EACH END

Instructor's Notes

Stores as for Lesson 101.

1. Explain that errors in direction are overcome by the
firer always traversing outside the flanks by one tap.

2. Explain that in engaging targets with width No. 1 gun will be laid on the right end, No. 2 on the left end. Each gun will engage the whole target. The engagement of a target in this way is known as *traversing*.

3. Illustrate.—

A fire unit engaging a target about 100 yards wide, at ranges up to 1,200 yards obtained by range-finder. (Fig. 15.)

    i. x . . . x are the original points of aim.

    ii. The dotted beaten zones on the flanks of the target represent one tap outside. (*See* para. 1, above.)
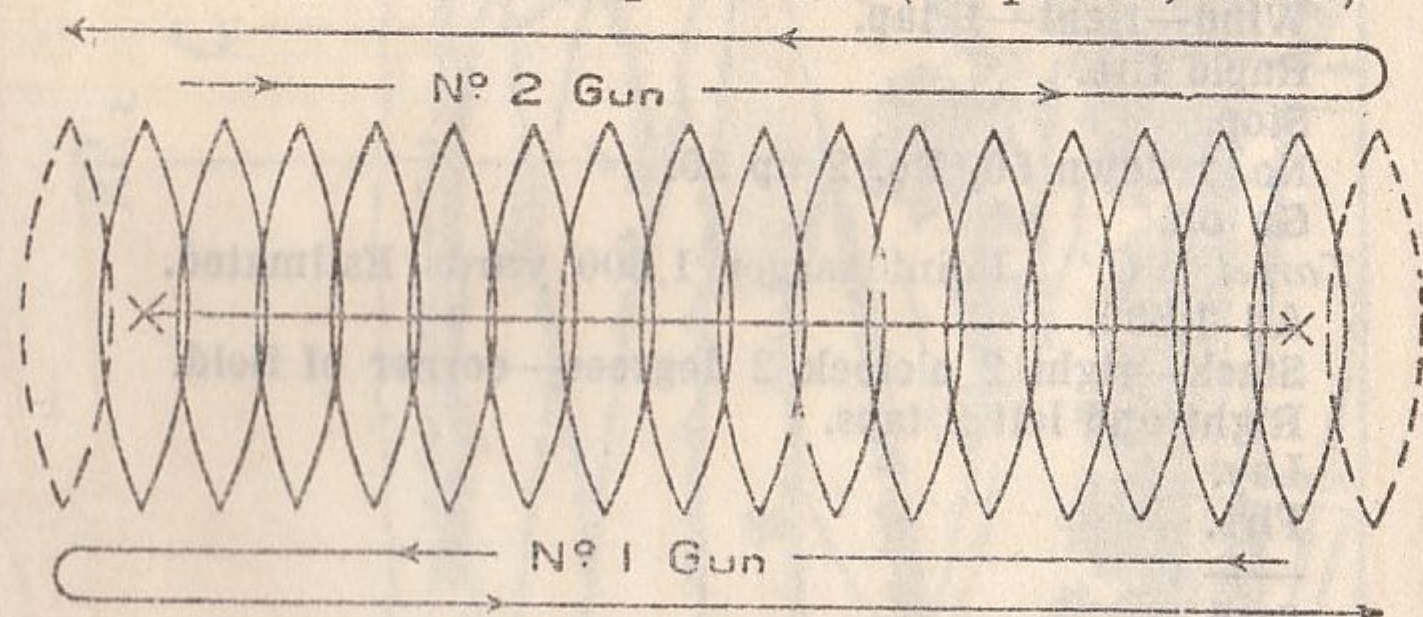
Fig. 15.—Traversing

4. With the aid of the spotlight apparatus practise the engagement of targets with width.

5. Examples of fire orders to engage targets with width.

The following reference points have been selected on the landscape as shown in Plate 24.

    i. Haystacks (R.P.1) left bottom corner known as **Stack.**

    ii. Two poplars (R.P.2) left poplar known as **Poplar.**
Reference to Plate 24.

Target "E." Target with width 800 yards (estimated).
    All 800.
    Poplar—6 o'clock right end of house—left limit.
    Right 3 o'clock 2 degrees—bush—right limit.
    Traversing.
    Lay.
    Rapid fire.

Target "F." Target with width, range 1,300 yards (estimated).
    All 1,300.
    Poplar—right 4 o'clock 4 degrees—bush—from bush to left 9 o'clock—where hedgerow disappears behind large trees.

PLATE 24
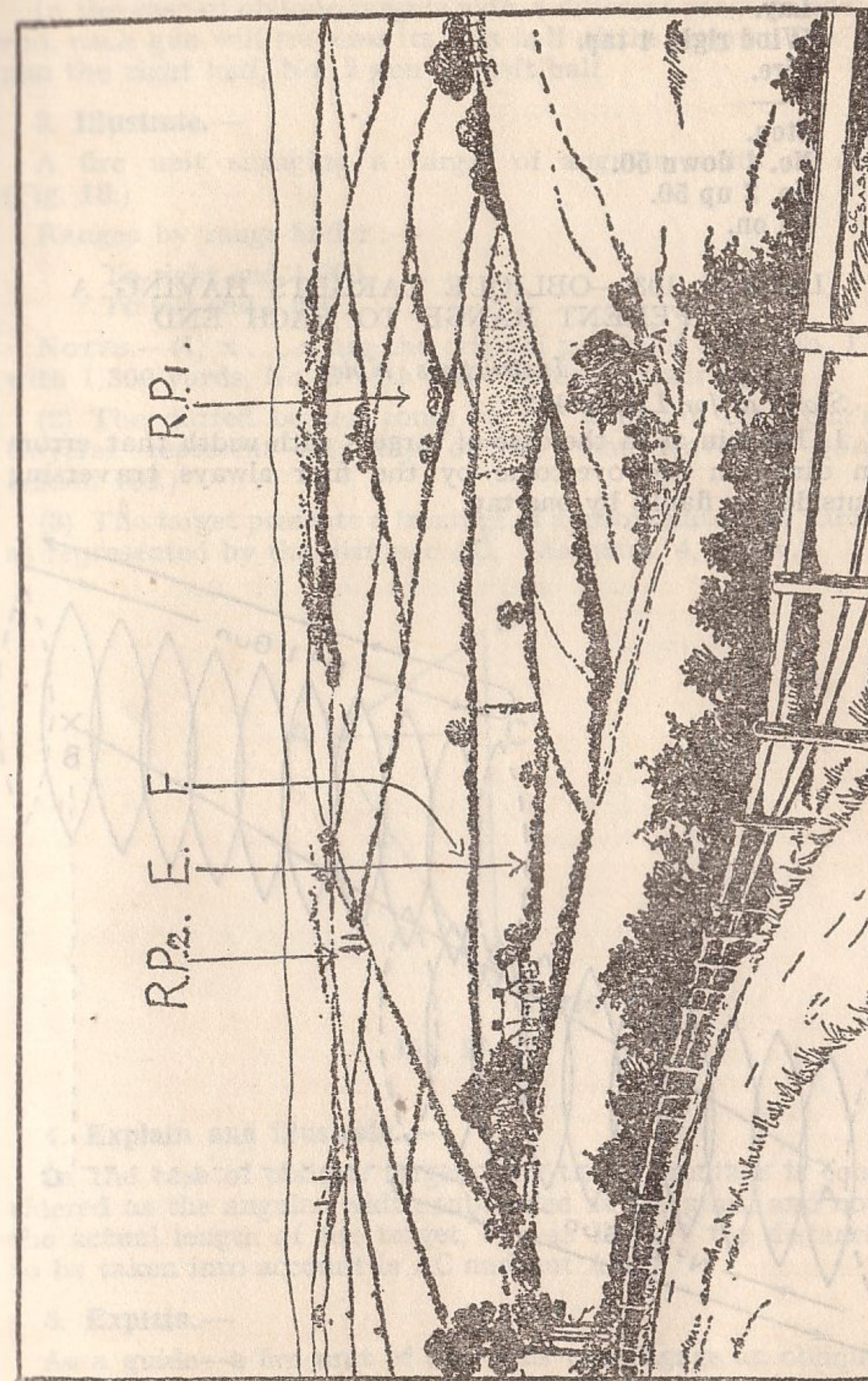
Traversing.
Lay.
Wind right 1 tap.
Fire.

———

Stop.
No. 1 down 50.
No. 2 up 50.
Go on.

LESSON 103.—OBLIQUE TARGETS HAVING A DIFFERENT RANGE TO EACH END

Instructor's Notes

Stores as for Lesson 102.

1. Explain as in the case of targets with width that errors in direction are overcome by the firer always traversing outside the flanks by one tap.
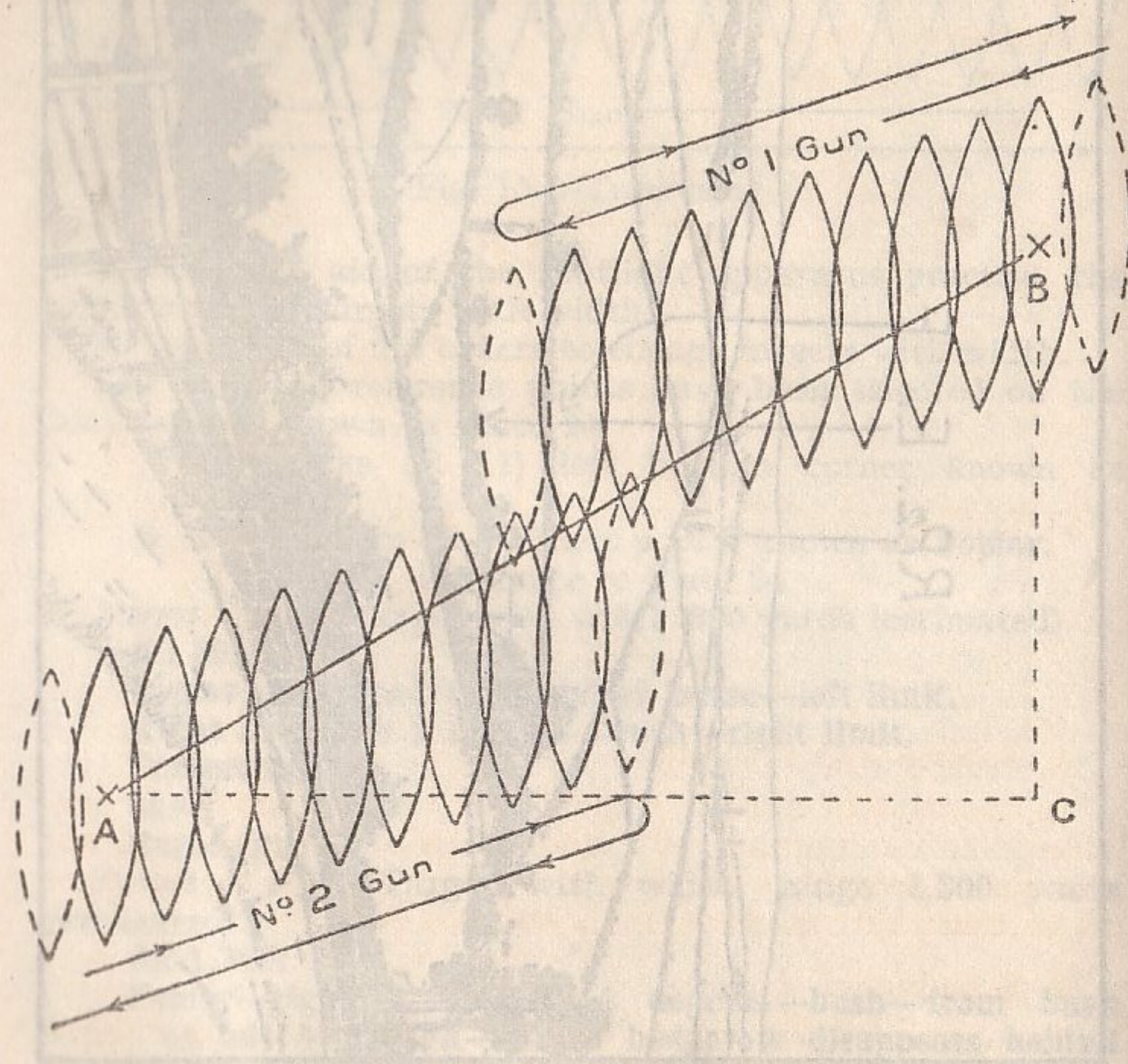
Fig. 16.—Traversing oblique target

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2. Explain.—

In the case of oblique targets with a different range to each end, each gun will traverse its own half of the target: No. 1 gun the right half, No. 2 gun the left half.

3. Illustrate.—

A fire unit engaging a target of angular width of 4°. (Fig. 16.)

Ranges by range-finder :—

To right end 1,300.
To left end 1,200.

NOTES.—(1) x . . . x are the original points of aim—No. 1 with 1,300 yards, No. 2 with 1,200 yards on their sights.

(2) The dotted beaten zones on the flanks of each gun's traverse represent one tap outside that traverse. (*See* Lesson 102.)

(3) The target presents a frontage of approximately 90 yards as represented by the distance AC. (*See* para. 4, below.)
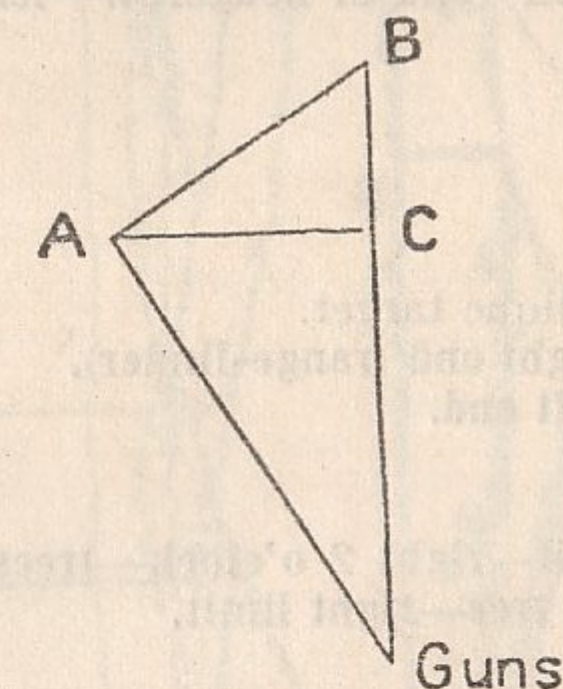
Fig. 17.

4. Explain and illustrate.—

In the case of oblique targets, the target frontage is considered as the angular width subtended at the guns, and not the actual length of the target, *e.g.*, in Fig. 17 the distance to be taken into account is AC and not AB.

5. Explain.—

As a guide—a fire unit of two guns can engage an oblique target when the difference in range between the two ends is

less than about 100 yards. If the difference exceeds that distance, only a portion of the target should be engaged at one time.

6. With the aid of the spotlight apparatus, practise the engagement of oblique targets.

7. Examples of fire orders to engage oblique targets.

The following reference points have been selected on the landscape as shown in Plate 25.

    i. Haystacks (R.P.1) left bottom corner known as **Stack.**

    ii. Two poplars (R.P.2), left poplar known as **Poplar.**

Reference to Plate 25.

Target " G." Oblique target.

    1,250 yards right end (range-finder).

    1,150 yards left end.

No. 1, 1,250.

No. 2, 1,150.

Poplar—left 8 o'clock—junction of hedgerow—**right limit** —left 8 o'clock—end of hedgerow—**left limit.**

No. 1 right half.

No. 2 left half.

Traversing.

Lay.

Fire.

Target " H." Oblique target.

    1,600 yards right end (range-finder).

    1,500 yards left end.

No. 1 1,600.

No. 2 1,500.

Poplar—left limit—right 2 o'clock—trees at right end of church—right tree—**right limit.**

No. 1 right half.

No. 2 left half.

Traversing.

Lay.

Wind left 2 taps.

Fire.

Stop.

All down 50.

Go on.

Stop.

All up 100.

Go on.

PLATE 25.
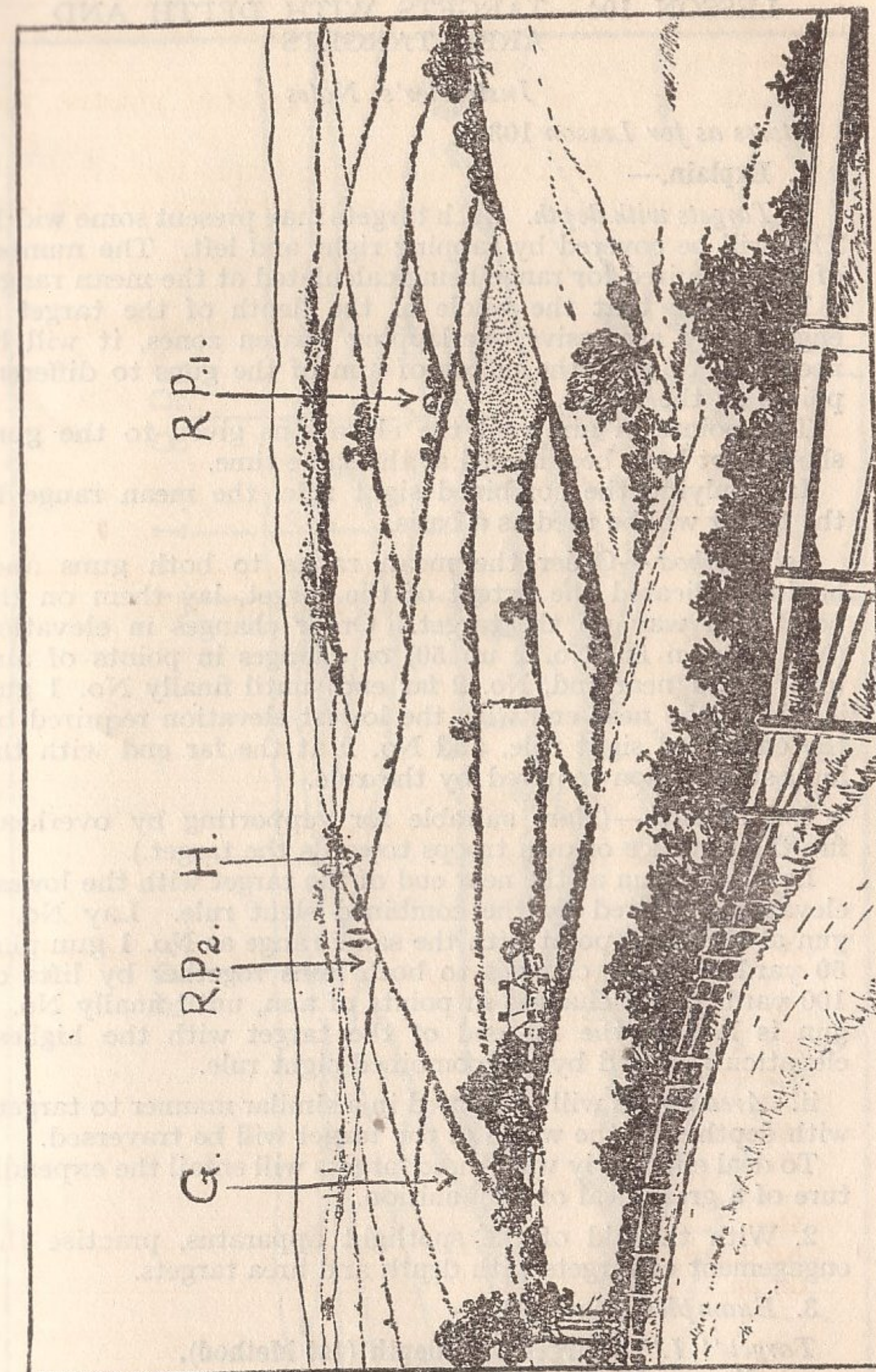
LESSON 104.—TARGETS WITH DEPTH AND AREA TARGETS

Instructor's Notes

Stores as for Lesson 103.

1. Explain.—

i. *Targets with depth.* Such targets may present some width. This will be covered by tapping right and left. The number of taps required for range being calculated at the mean range.

To ensure that the whole of the depth of the target is engaged by successive overlapping beaten zones, it will be necessary to alter the points of aim of the guns to different points on the target.

The points of aim and the elevations given to the guns should not both be changed at the same time.

In applying the combined sight rule, the mean range to the target will be used as a basis.

1st Method.—Order the mean range to both guns and, having indicated the extent of the target, lay them on the point half way up the target. Order changes in elevation (No. 1 down 50, No. 2 up 50) *or* changes in points of aim (e.g., No. 1 near end, No. 2 far end) until finally No. 1 gun is laid at the near end with the lowest elevation required by the combined sight rule, and No. 2 at the far end with the highest elevation required by the rule.

2nd Method.—(More suitable for supporting by overhead fire the advance of own troops towards the target.)

Lay No. 1 gun at the near end of the target with the lowest elevation required by the combined sight rule. Lay No. 2 gun at the same point with the same range as No. 1 gun plus 50 yards. Order changes to both guns together by lifts of 100 yards or by changes in points of aim, until finally No. 2 gun is laid at the far end of the target with the highest elevation required by the combined sight rule.

ii. *Area targets* will be treated in a similar manner to targets with depth, but the width of the target will be traversed.

To deal effectively with these targets will entail the expenditure of a great deal of ammunition.

2. With the aid of the spotlight apparatus, practise the engagement of targets with depth and area targets.

3. *Examples* (Plate 26) :—

Target " I." **Target with depth (1st Method).**

Near end	1,400 (range-finder).
Far end	1,600 (range-finder).

PLATE 26

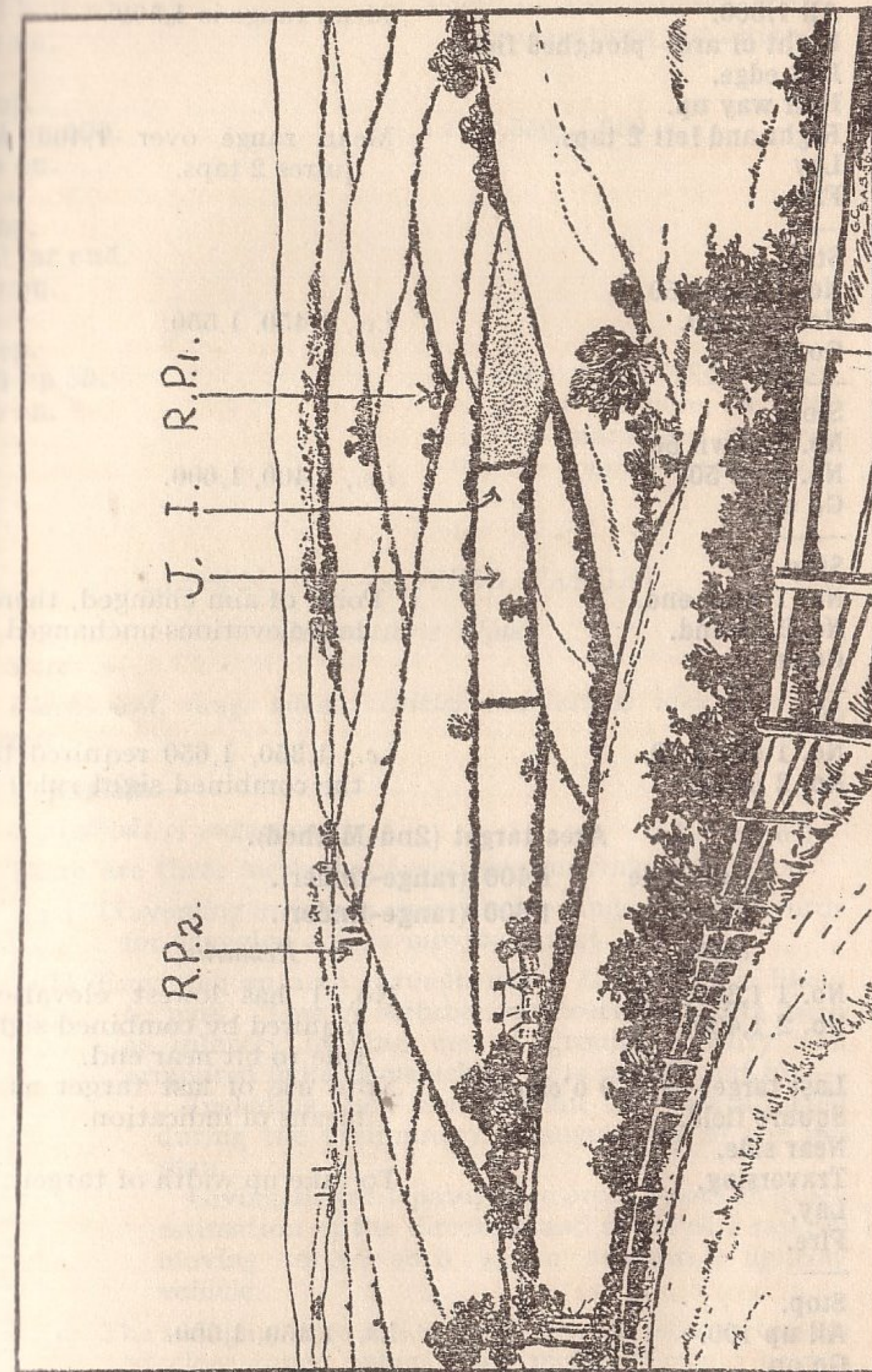| Order.	Remarks.
All 1,500.	Mean range is 1,500.
Right of arc—ploughed field.	
Left edge.	
Half way up.	
Right and left 2 taps.	Mean range over 1,400 requires 2 taps.
Lay	
Fire.	
Stop.	
No. 1 down 50.	
No. 2 up 50.	*i.e.*, 1,450, 1,550.
Go on.	
Stop.	
No. 1 down 50.	
No. 2 up 50.	*i.e.*, 1,400, 1,600.
Go on.	
Stop.	
No. 1 near end.	Point of aim changed, therefore elevations unchanged.
No. 2 far end.	
Go on.	
Stop.	
No. 1 down 50.	*i.e.*, 1,350, 1,650 required by the combined sight rule.
No. 2 up 50.	

Target " J."   Area target (2nd Method).

Near side	1,400 (range-finder).
Far side	1,600 (range-finder).

Order.	Remarks.
No. 1 1,350.	No. 1 has lowest elevation required by combined sight rule to hit near end.
No. 2 1,400.	
Last target—left 9 o'clock.	Note use of last target as a means of indication.
Square field.	
Near side.	
Traversing.	To take up width of target.
Lay.	
Fire.	
Stop.	
All up 100.	*i.e.*, 1,450, 1,500.
Go on.	

Stop.	
All half way up.	Point of aim altered, therefore elevations not altered.
Go on.	
Stop.	
All up 100.	*i.e.*, 1,550, 1,600.
Go on.	
Stop.	
All far end.	
Go on.	
Stop.	
All up 50.	*i.e.*, 1,600, 1,650. No need for a lift of 100 here, as 1,650 is the maximum required by the combined sight rule.
Go on.	

LESSON 105.—MOVING TARGET.

Instructor's Notes

Stores :—

Blackboard, range tables, vehicles and fatigue men to act as targets.

1. Explain.—

i. *Methods of engagement.*

There are three methods of engaging moving targets :—

(a) Traversing in front ; suitable for range over 800 yards for engaging a slow moving target.

(b) Engaging an area through which the target is likely to pass. This is suitable for fleeting targets, such as infantry making use of ground, cavalry and armoured fighting vehicles. It is carried out by :—

Including such areas within the area allotted during the preliminary arrangements of the fire plan.

Giving an anticipatory fire order based on quick estimation of the direction and speed of a rapidly moving target such as an armoured fighting vehicle.

(c) The swinging traverse, suitable against moving targets at close range, when other methods would be too slow.

ii. *Fire control.*

(a) Fire orders must be simple and as short as possible, otherwise the opportunity of engaging the target may be lost.

(b) The fire unit commander will maintain control until, owing to the closeness of the range or other factors, greater fire effect may be expected from gun control. He must change to gun control before unit fire control breaks down.

(c) When engaging a moving target, whether by section or gun control, attention must be continually directed to :—

The changing line of sight, horizontally and vertically.
The alterations in range.
The maximum effect will only be obtained by quick judgment and a thorough knowledge of the machine gun beaten zones. Fire should be directed in front of the target rather than on to it.

Bearing in mind the limited time that an armoured fighting vehicle will take to pass through the beaten zones, a burst of fire should be of 50-60 rounds, in order to ensure the maximum weight of fire during this period.

2. Refer to range table.—Allowance for moving targets.

3. Practise in the open on targets at varying speeds and distances.

SECTION 25.—INDIRECT FIRE

1. The indirect fire unit is normally the platoon because :—

i. The gun position is not in view of the enemy, and therefore concealment and control of four guns is possible.

ii. Indirect fire is usually employed at the longer ranges, when the fire of four guns is desirable to produce the requisite volume.

The platoon, however, carries the necessary equipment for sections to employ indirect fire independently. In an indirect fire position the normal gun interval is 15 yards.

2. The opening of fire rapidly and effectively by indirect means depends on accuracy in the use of the various instruments and minute precision in drill. This can only be attained by a high standard of training and frequent practice.

3. The principles and methods laid down in the following sections apply to any number of machine guns that may be grouped together as a fire unit under one fire controller.

The platoon is referred to throughout for reasons of brevity and simplicity.

It must be realised that the diagrams are not drawn to scale.

LESSON 106.—FIRE ORDERS—INDIRECT

Stores :—

Blackboard, range tables.
The lesson should be carried out in the form of a lecture.

1. **Explain.**—

The following is the procedure for engaging a target by indirect fire :—

The methods of laying guns by indirect means consist of giving direction to the guns by laying off a point seen from the gun position. Elevation is calculated from the horizontal plane, and is placed on the gun by means of the dial sight. Both direction and elevation are maintained by means of an aiming mark, usually an aiming post placed in front of the guns. The clinometer level is another check on the elevation.

2. The form of orders given and the action to be taken will be found in Sec. **18**.

The sequence of an indirect fire order will be :—

    i. Zero lines.
    ii. Angles of switch.
    iii. Elevation or elevations.
    iv. Load.
    v. Distribution (if any).
    vi. Tapping right and left.
    vii. Side wind allowance.
    viii. Rate of fire (if required).
    ix. Order to fire (as for direct fire).

3. Notes on indirect fire orders.—

i. *Zero lines.* (Lesson 107.)

Before giving out angles to the respective guns, the order " **zero lines** " will be given. The angles are given to the nearest ten minutes.

ii. *Elevation or elevations.* (Lesson 114.)

If a correction for atmospheric influences is necessary, it will be added to, or subtracted from, the angle of sight or Q.A. before the latter is given out. (Lesson 97.)

Angles of sight and quadrant angles are converted to the nearest 5′ before being passed to the guns.

The elevation is given to the guns as under :—

All (or No. . . .) . . . hundred.

Plus (or minus.) . . . degrees . . . mins.

        or

Elevation all (or No. . . .) . . . degrees . . . mins.

iii. *Distribution.* (Lesson 113.)

The order for distribution will always start with the pivot gun, for which the order " **nil** " is given. The angles of deflection for the other guns are given to the nearest 10′.

iv. *Tapping right and left.*

The amount of traverse will be given in " taps," as for direct fire.

Nos. 1 and 2 guns tap to the left, first, Nos. 3 and 4 to the right first.

v. *Side wind allowance.* (Lesson 97.)

The allowance is calculated for the range from the gun position, and ordered to the nearest 10′.

4. Orders during a shoot.

i. *Lifts.*

If in yards will be given to the guns in the form :—

" **All—up . . . (hundred or fifty).** "

If in minutes will be determined from the range table, and given in the form—

" **All—up . . . mins.** "

This order may be given verbally or by signal as detailed in sub-para. ii (*b*), below.

ii. *Ranging corrections.*

(*a*) Direction.

The amount of switch required is measured by the director, glasses, or by slide rule according to the time available.

The correction may be given verbally, or the following semaphore signals may be employed :—

T . . . right 30′.

L . . . left 30′.

To double or increase further the corrections, the code letter will be repeated as necessary.

(*b*) Elevation.

The fire controller estimates the correction required in hundreds of yards, and orders the result in the form :—

All—up (or down) . . . (hundred or fifty).

This order may be sent by semaphore signal as follows :—

U . . . up 50 yards or 10′.

N . . . down 50 yards or 10′.

To double or increase further the correction, the code letter will be repeated as necessary.

If during the shoot it is seen that any gun or guns are firing over or short as compared with the remainder, the order " **check elevations** " will be given.

iii. *The engagement of a fresh target.*

(*a*) Direction.

The fire controller measures the angles of switch for the pivot gun as in sub-para. ii (*a*), above. So that the lines of fire may be parallel, before switching, he will order the guns to relay on their zero lines with dial sights at zero, by giving the order :—

All—on zero lines.

The angle of switch is then given out verbally, or by signal.

If the switch is very large, it may be convenient to correct the zero line on to the new target ; in this case, the order for

the angle of switch will be preceded by the words " **zero lines.**" When time allows, the aiming posts should be put out to suit the new zero line.

(b) *Elevation.*

The angle of sight to the new target is taken with a director.

The elevation for the new target is calculated and ordered to the guns as in 3 (ii), above.

(c) The remainder of the fire order is normal, depending on the type of target.

(d) During pauses in the firing, and at any other time when it is possible, it is the duty of the fire controller to measure switches, and, with the assistance of his range-taker, calculate the elevation for all probable targets in his arc. This may reduce the time taken to open fire on new targets.

LESSON 107.—GENERAL PRINCIPLES

Instructor's Note

Stores :—

Blackboard.

1. Explain.—

i. *Zero lines.*

Lines which are parallel, when swung through the same angle, remain parallel.

Therefore, to provide a basis from which fire can be switched in any direction, all guns are, by various means, initially placed on parallel zero lines. (*See* Fig. 18.)

The choice of the actual direction of the zero lines is arbitrary but they are generally laid out so that the line of fire of one of the guns will fall on its correct position on the first target, either directly or after an angle of switch has been given. This gun is known as the pivot gun, and is usually one or other of the flank guns.

ii. *Gun frontage.*

The gun frontage is the distance between the flank guns, normally 45 yards for a platoon. When the line of fire is approximately at right angles to the gun position, which is usual, it can be seen from Fig. 19 that the width which is covered by the lines of fire of a platoon on parallel lines is equal to the gun frontage. As the guns are approximately equidistant from one another, the lines of fire of Nos. 2 and 3 guns divide this width into three equal parts, namely, AB, BC, CD.
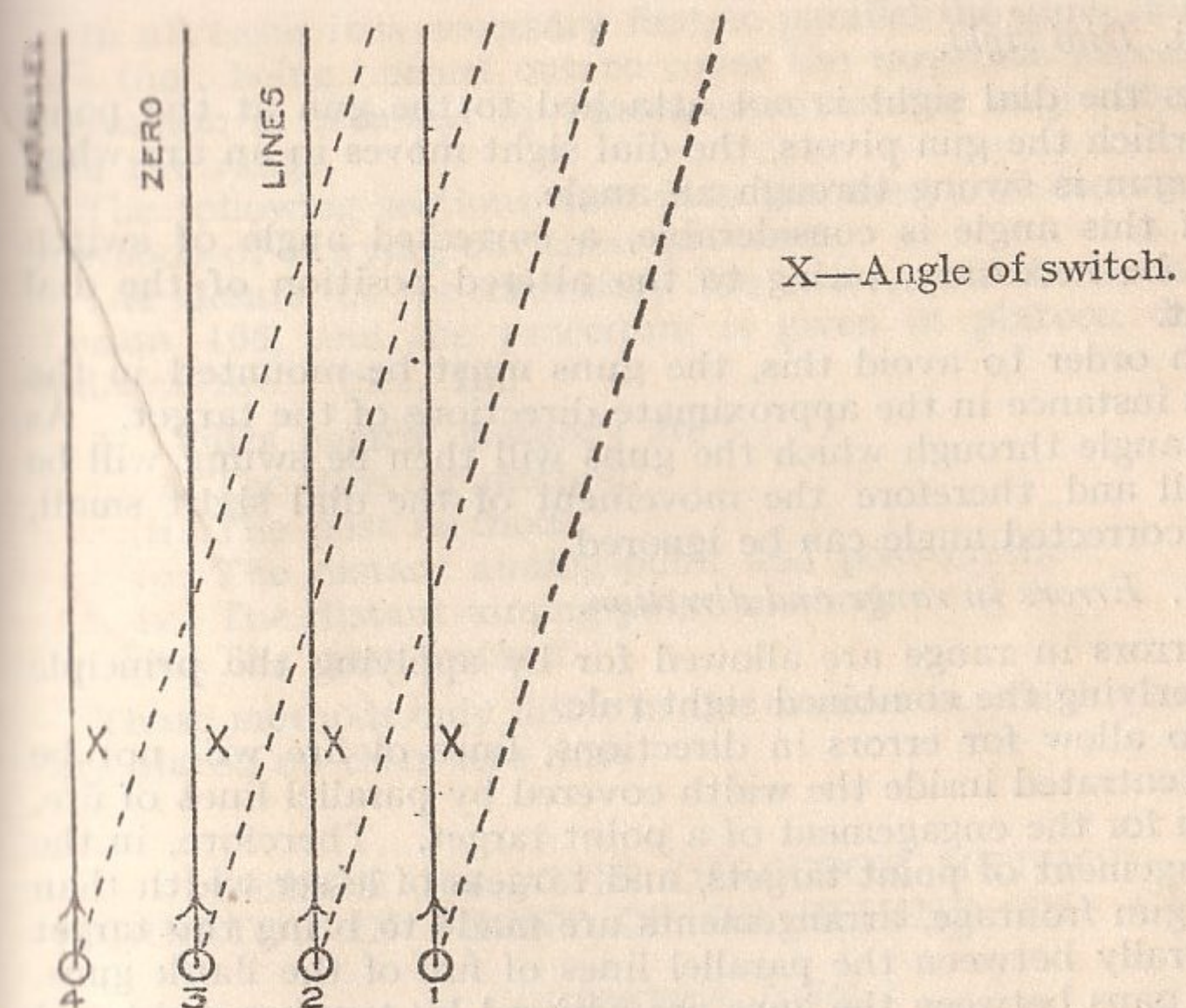
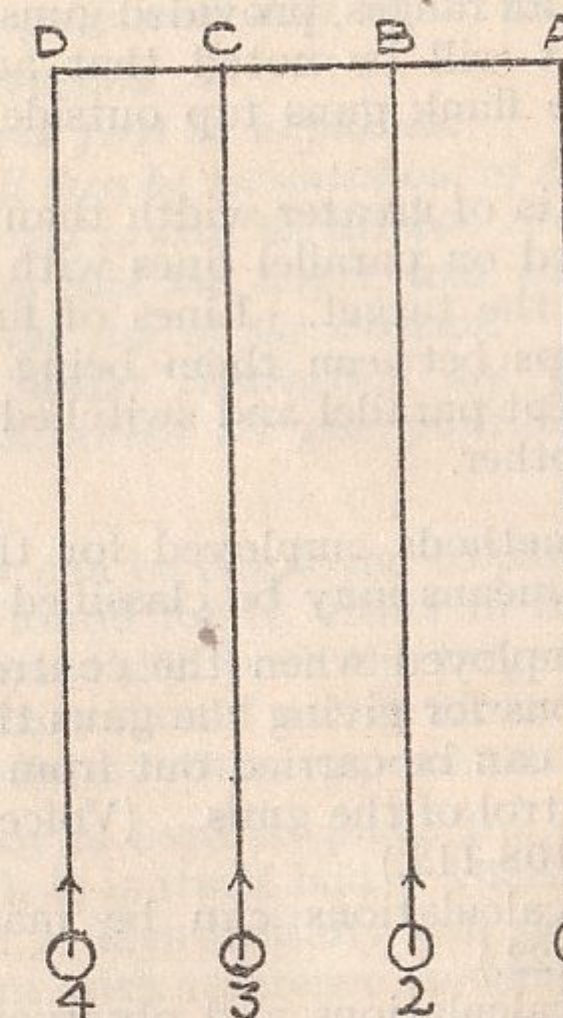X—Angle of switch.

Fig. 18.

Fig. 19.

iii. *Dial sight.*

As the dial sight is not attached to the gun at the point at which the gun pivots, the dial sight moves in an arc when the gun is swung through an angle.

If this angle is considerable, a corrected angle of switch will be necessary, owing to the altered position of the dial sight.

In order to avoid this, the guns must be mounted in the first instance in the approximate directions of the target. As the angle through which the guns will then be swung will be small and therefore the movement of the dial sight small, the corrected angle can be ignored.

iv. *Errors in range and direction.*

Errors in range are allowed for by applying the principle underlying the combined sight rule.

To allow for errors in directions, lines of fire will not be concentrated inside the width covered by parallel lines of fire, even for the engagement of a point target. Therefore, in the engagement of point targets, and targets of lesser width than the gun frontage, arrangements are made to bring the target centrally between the parallel lines of fire of the flank guns. The gaps between the guns are covered by tapping right and left one tap, this being sufficient to cause the beaten zones to overlap laterally at all ranges, provided guns are not more than 15 yards apart. It will be noted that additional width is covered in that the flank guns tap outside the gun frontage by one tap.

When the target is of greater width than the gun frontage, guns are first placed on parallel lines with the pivot gun on its own portion of the target. Lines of fire are then either opened out, the gaps between them being filled by tapping right and left, or kept parallel and switched from one portion of the target to another.

2. The various methods employed for the engagement of targets by indirect means may be classified as under :—

    i. Methods employed when the control of fire and the calculations for giving the guns their elevation and direction can be carried out from a position within voice control of the guns. (Voice control methods. Lessons 108-112.)

    ii. When all calculations can be made from a map. (Lesson 122.)

    iii. When the calculations and observations of fire have to be carried out at some distance from the guns. (Lesson 123.)

In all cases it is necessary first to parallel the guns, lines of fire then being opened out to cover the target as necessary. Elevation is obtained by measurement of the angle of sight and the range.

The following sections deal with the theory of the various methods of carrying out these processes.

The details of the necessary fire orders will be found in Lesson 106, and the procedure is given in platoon drill—indirect fire. (Sec. **18.**)

3. **Voice control** methods are :—
    i. The director method.
    ii. The post method.
    iii. The distant aiming-point and post method.
    iv. The distant aiming-point method.
    v. The crest method.

These methods only differ in the manner in which the guns are placed on their zero lines.

LESSON 108.—THE DIRECTOR METHOD (DIRECTOR IN FRONT OF OR BEHIND THE GUNS)

Instructor's Notes

Stores :—

    Director, two guns with dial sights and tripods, blackboard.

Method of instruction :—

    The theory will first be explained.

    The guns will then be mounted out of doors. The instructor will choose a target so that the director can be mounted between the gun position and the target, and will then give individual instruction in the use of the director.

    When those under instruction are proficient the director will be mounted behind the gun position.

1. **Explain.**—

i. The director can be employed to parallel the guns when a position can be found for it, either in front of or behind the gun position, from which both the target and the guns can be seen. This position should not be closer than 50 yards to the guns, nor more distant than approximately 150 yards.

ii. The director is used to place the guns on lines parallel to that on which it is itself laid. Therefore the point on the target on which it lays initially will depend on the position of the instrument with reference to the gun position.

For example, consider a target of the same width as the gun frontage. (Lesson 107.)

It is required to bring the line of No. 1 gun on to the right flank of the target (T₁, Fig. 25) and the remaining guns on parallel lines. Suppose the director is in position at 01.

In order that the zero line of No. 1 gun G₁T₁ should fall on the right flank of the target when placed parallel to the initial line of the director sight, it will be necessary for the director to be laid as much to the left of T₁, as its position is left of No. 1 gun, that is at X₁.
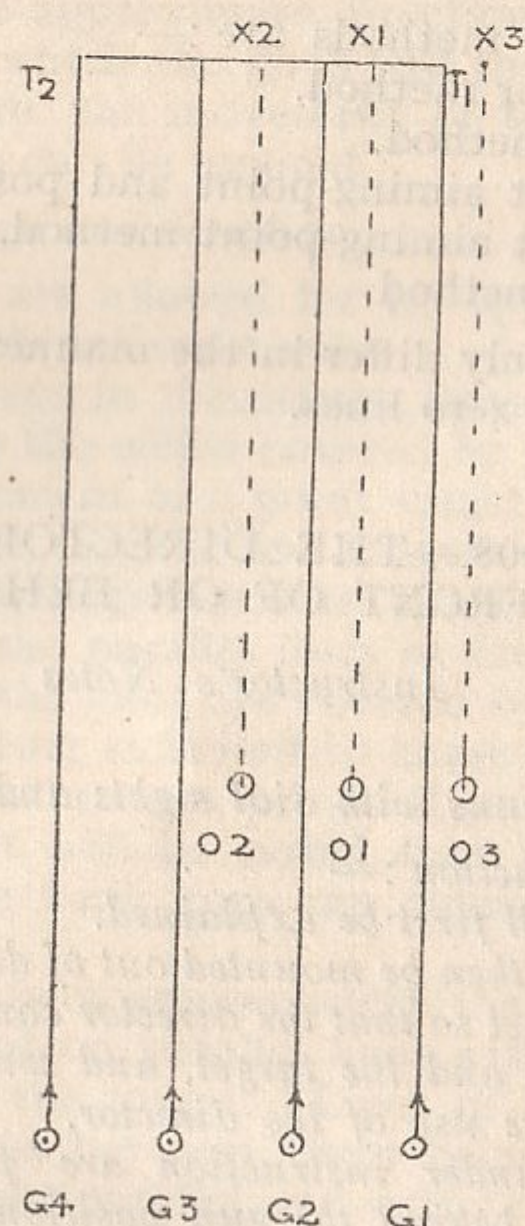
Fig. 20.

Similarly, if the director were at 02 in the centre of the gun position, it must be laid at X2 in the centre of the target.

If it were at 03 outside the gun line, it must be laid at X3.

iii. In practice, the position at which the director is set up will depend on the type of target. For targets with width equal to, or greater than, the gun frontage, a position as near as possible to the required zero line of one of the flank, guns is most suitable. For point targets or targets of little width a central position will give the best results.

2. Procedure.—

i. Set up the director in front of or behind the gun position with the arrow on the index plate set at 180° on the degree scale plate, and the index plate clamp tightened.

ii. Loosen the clamping screw of the clamping socket and lay the telescope on the selected point of aim on the target. Tighten the clamping screw.

iii. Release the index plate clamp and lay on the collimator of the dial sight of each gun in turn.

Read the angle for each gun off the degree scale and give it out to the gun concerned.

Each gun puts on its dial sight the angle ordered and lays on the director. Guns will then be on lines parallel to the initial line on which the director was laid.

3. Theory.—

Reference Fig 21, X is the point of aim on the target selected for the director.

Fig. 21.

QOG is the line joining the director and the gun.

It is desired to place GT parallel to OX.

If the angle TGQ is made equal to XOQ, GT will be parallel to OX.

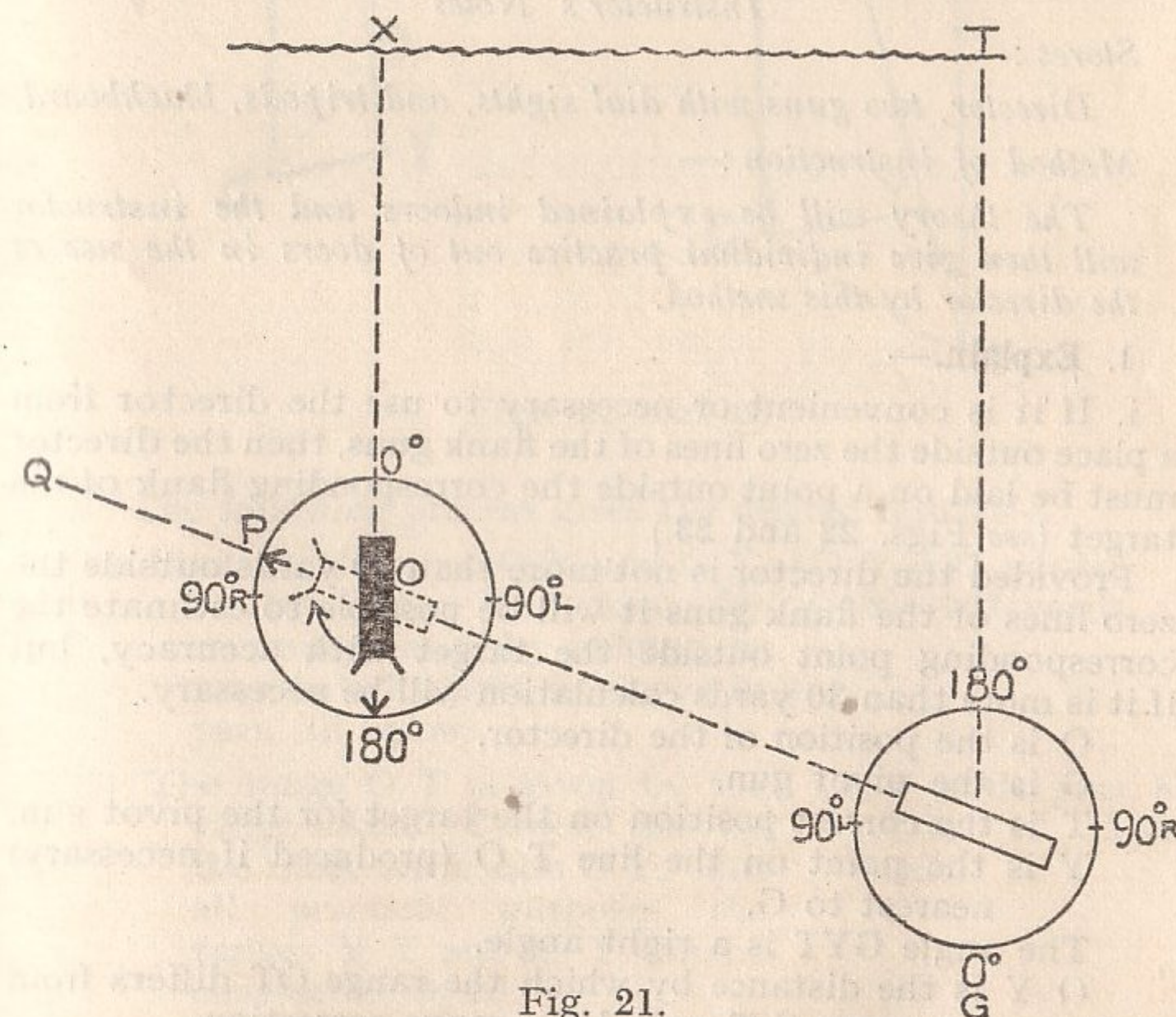The position of the telescope when the arrow on the index plate is set at 180° and the telescope laid on the target is shown at O in black. When the telescope is swung round and laid on the collimator, it will be in the dotted position and the arrow on the index plate will have moved round from 180° to a position P on the degree scale plate. As the scale on the degree scale plate runs from 0° through 90°R to 180° as shown in the figure, it can be seen that the reading opposite P will be that for the angle XOQ. The angle XOQ having been set on the direction dial of the dial sight, the gun is laid, by means of the dial sight, on the director.

Thus the angles XOQ and T.G.Q are equal, and therefore GT and OX are parallel.

LESSON 109.—DIRECTOR TO THE FLANK OF THE LINE OF FIRE

Instructor's Notes

Stores :—

Director, two guns with dial sights, and tripods, blackboard.

Method of instruction :—

The theory will be explained indoors and the instructor will then give individual practice out of doors in the use of the director by this method.

1. Explain.—

i. If it is convenient or necessary to use the director from a place outside the zero lines of the flank guns, then the director must be laid on a point outside the corresponding flank of the target (*see* Figs. 22 and 23.)

Provided the director is not more than 30 yards outside the zero lines of the flank guns it will be possible to estimate the corresponding point outside the target with accuracy, but if it is more than 30 yards calculation will be necessary.

O is the position of the director.

G is the pivot gun.

T is the correct position on the target for the pivot gun.

Y is the point on the line T O (produced if necessary) nearest to G.

The angle GYT is a right angle.

O Y is the distance by which the range OT differs from the range G T, called the range correction.

G Y is the distance of the displacement of the director, called the true base.

A simple method of laying the director along the required line O X is to find the angle G T O which is equal to the angle

T O X when the lines G T and O X are parallel, and then to lay the 180-0 degrees line of the director outside the flank of the target by that angle.
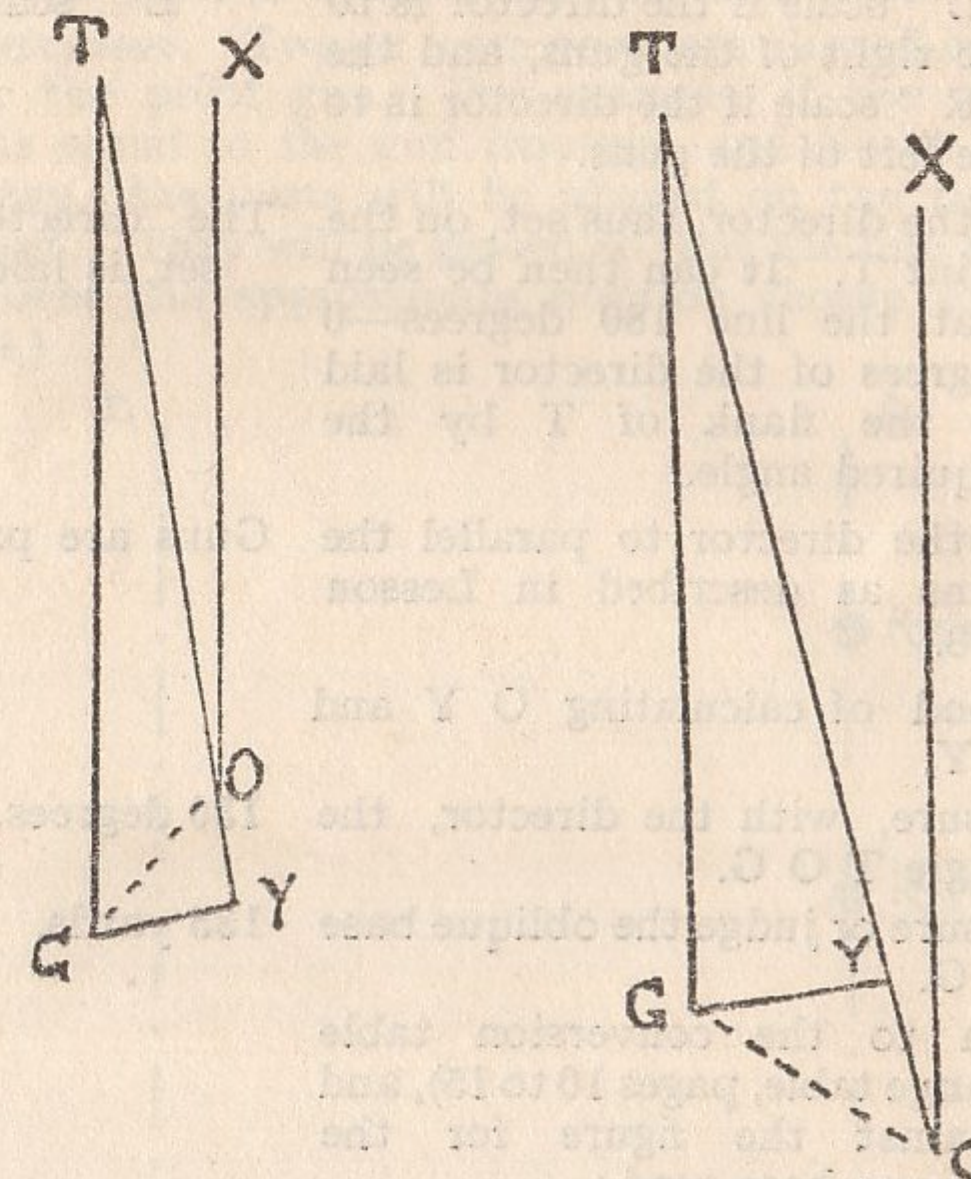
Figs. 22 and 23.

ii. The following process gives the desired result :—

(a) Find the distance O Y and G Y. O Y=87 yards. This may be done by G Y=103 yards. measurement or by judging, or may be calculated as shown in para. iii below.

(b) The range O T is given by the range-taker. Correct this by the range correction O Y. For all practical purposes the ranges Y T and G T can be considered equal. 1,920 yards plus 87 yards is 2,007 yards.

(c) From the slide rule or the V.I. Graph in the Range Table, find the angle subtended by the true base G Y at the gun range G T. 103 yards at 2,000 yards subtends three degrees.

(d) Set the pointer of the director away from the 180 degrees mark by this angle, using the "L" scale if the director is to the right of the guns, and the "R" scale if the director is to the left of the guns.

Director is set three degrees away from 180 degrees on the "L" scale.

(e) Lay the director, thus set, on the point T. It can then be seen that the line 180 degrees—0 degrees of the director is laid to the flank of T by the required angle.

The director, thus set, is laid on T.

(f) Use the director to parallel the guns as described in Lesson 108.

Guns are paralleled.

iii. Method of calculating O Y and G Y.

(a) Measure, with the director, the angle T O G.

130 degrees.

(b) Measure or judge the oblique base O G.

135 yards.

(c) Turn to the conversion table (range table, pages 10 to 15), and against the figure for the oblique base read :—
Under the angle T O G in the upper heading, the range correction O Y.

87 yards.

Under the angle T O G in the lower heading the true base G Y.

103 yards.

NOTE.—O Y and G Y can be calculated on the slide rule (see Lesson 40).

LESSON 110.—POST METHOD

Instructor's Notes

Stores :—

Two (or more) guns with tripods and dial sights. Two zero posts. Blackboard.

Method of instruction :—

The theory will be explained indoors and the instructor will then give individual practice out of doors.

Explain.—

i. This method is suitable when the guns can be brought into action close behind a crest, and the use of the director to parallel the guns is inconvenient or inadvisable.

ii. *Procedure.* Two or more posts are aligned on the correct line for the pivot gun. For example, if the width of the target is equal to the gun frontage, and No. 1 is to be the pivot gun, the posts will be aligned on the right flank of the target. They will be placed so that the line joining them passes over the approximate position chosen for that gun. (Fig. 24.)
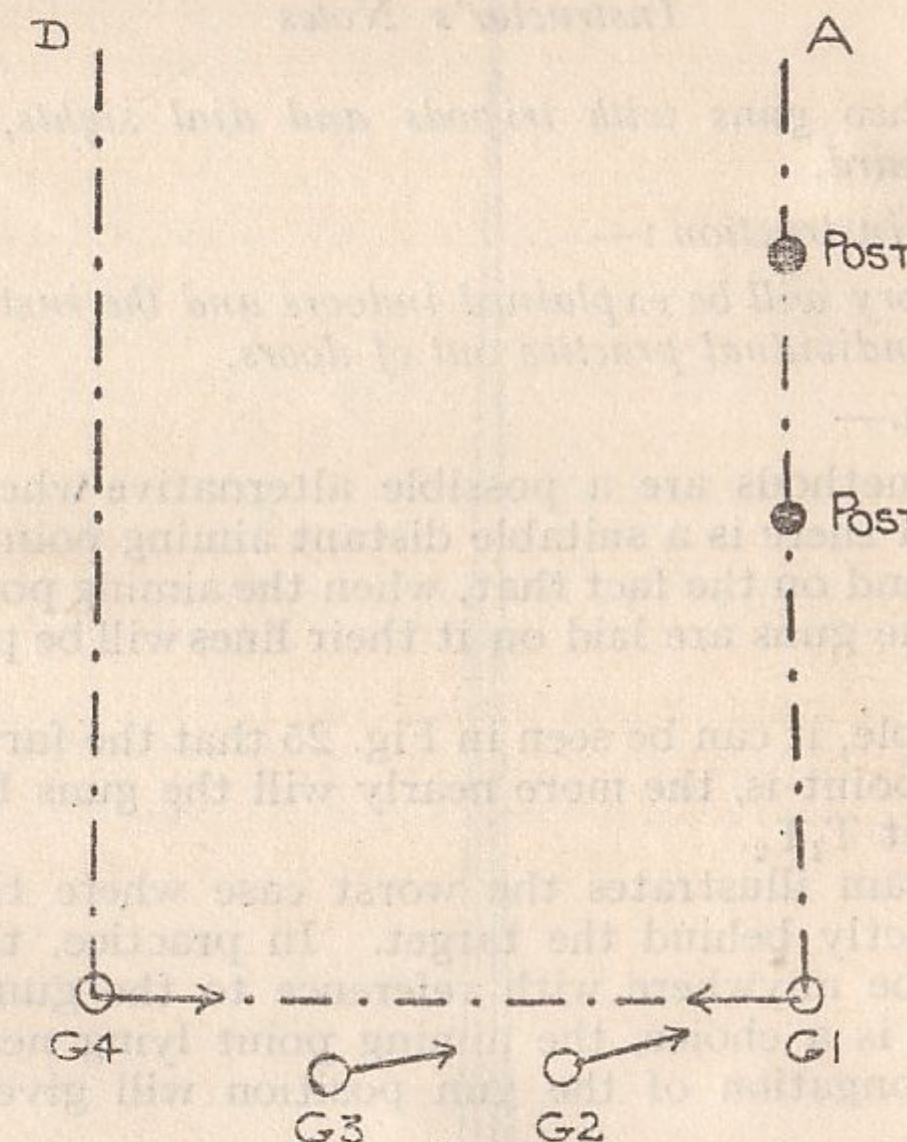
Fig. 24.

Both posts, or any two, if more than two have been used, must be visible from this position at gun height. When the guns are brought up the pivot gun is mounted in direct alignment with the posts with its dial sight at zero, and the gun is laid on them. It will then be on its zero line.

The remaining guns are mounted so that they have an uninterrupted view of the pivot gun, and can be placed on parallel lines to the pivot gun, as follows :—

(a) The dial sight of the pivot gun is laid on the collimator of the dial sight of each other gun in turn and the angle read out, using the front pointer.

(b) The other guns put on their dial sights their respective angles as ordered and then tap their guns until their dial sights are laid on the collimator of the dial sight of the pivot gun.

(c) When this process is complete, all guns will be parallel and dial sights will then be reset at zero.

LESSON III.—A. DISTANT AIMING POINT AND POSTS METHOD—B. DISTANT AIMING POINT METHOD.

Instructor's Notes

Stores :—

Director, two guns with tripods and dial sights, two zero posts, blackboard.

Method of instruction :—

The theory will be explained indoors and the instructor will then give individual practice out of doors.

1. **Explain.**—

i. These methods are a possible alternative when speed is essential and there is a suitable distant aiming point.

They depend on the fact that, when the aiming point is very distant, if the guns are laid on it their lines will be practically parallel.

For example, it can be seen in Fig. 25 that the farther away the aiming point is, the more nearly will the guns be parallel on the target $T_1 T_2$.

The diagram illustrates the worst case where the aiming point is exactly behind the target. In practice, the aiming point may be anywhere with reference to the gun position. When there is a choice, the aiming point lying nearest to a line in prolongation of the gun position will give the best results.

ii. For this method to be effective certain conditions must be fulfilled :—

(a) When the aiming point is in prolongation of the gun position it may be as close as 1,000 yards.

(b) When the line joining the aiming point to the gun position is at an angle of not more than about half a right angle to the gun position or the gun position produced, the aiming point may be as close as 4,000 yards.

(c) When the line joining the aiming point to the gun position is at a greater angle than this to the gun position, the aiming point should be about 7,000 yards distant.

2. **Procedure.**—

A. *Distant aiming point and posts method.*

A director is mounted in direct prolongation of the posts and the angle between the posts and aiming point is measured.
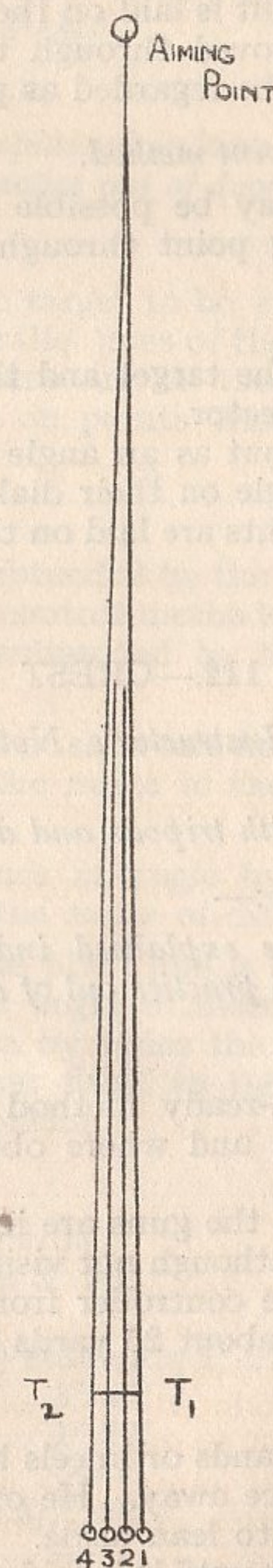

Fig. 25.

The guns are mounted with the pivot gun approximately over the spot from where the director measured the above angle.

This angle is given out as an angle of switch.

All guns put this angle on their dial sights, and are tapped over until their dial sight is laid on the aiming point.

As they have all moved through the same angle off the aiming point they can be regarded as parallel.

B. *Distant aiming point method.*

i. Occasionally it may be possible to see both the target and the distant aiming point through a director mounted in the gun position.

ii. Procedure.

The angle between the target and the distant aiming point is measured with a director.

This angle is given out as an angle of switch.

All guns set this angle on their dial sights, and are tapped over until their dial sights are laid on the distant aiming point.

LESSON 112.—CREST METHOD

Instructor's Notes

Stores :—

Two or more guns with tripods and dial sights.

Method of instruction :—

The theory will be explained indoors and the instructor will then give individual practice out of doors.

1. Explain.—

This is a rough-and-ready method for use at ranges not exceeding 1,500 yards, and where observation of strike will probably be obtained.

It can be used when the guns are in action just behind the crest, and the target, although not visible from the gun height, can be seen by the fire controller from any position directly behind the guns up to about 25 yards back.

2. Procedure.—

The fire controller stands or kneels behind each gun in turn at a convenient distance away. He orders the No. 1 to raise the tangent sight and to lean aside. He then orders him to tap the gun right or left until it is laid on to its correct position on the target.

LESSON 113.—DISTRIBUTION

Instructor's Notes

Stores :—

Director ; range tables and slide rules ; two or more guns (with tripods and dial sights).

Method of instruction :—

The theory will be explained indoors and the instructor will then give individual practice out of doors.

1. Explain.—

When the width of the target to be engaged is greater than the gun frontage, the parallel lines of the guns may be opened out so that the flank guns are on the flanks of the target, and the remaining guns on points which divide the target into three equal parts.

2. Procedure.—

i. Measure the angle subtended by the target at the observation post. In the voice control methods this can be taken as the same as the angle subtended by the target at the gun position.

ii. From the V.I. graph or slide rule find the angle subtended by the gun frontage at the range to the target, and subtract this angle from the first.

iii. Divide the difference in angle by the number of gun intervals. This will be the angle of distribution.

iv. The gun next to the pivot gun is swung away from the line of the latter by the angle of distribution, the gun two away from the pivot gun by twice the angle of distribution, and the gun on the other flank to the pivot gun by three times the angle of distribution.

Example :—

Range to target 1,800 yards.
Angular width of target 3° 50′.
No. 4 is pivot gun.
45 yards (gun frontage) subtends 1° 27′ at 1,800.

$$
\begin{array}{r}
3° 50' \\
1° 27' \\
\hline
3)2° 23' \\
\hline
48'
\end{array}
$$

Distribution—No. 4. Nil.

           No. 3. R. 50'.

           No. 2. R. 1° 40' (2×48').

           No. 1. R. 2° 20'.

NOTE.—Angles given out to guns to nearest 10'.

Note.—In the case of oblique targets having a different range to each end, the mean range will be used for calculating the angular width of the gun frontage.

3. Theory.

In Fig. 26.

T_1T_2 is the target.

No. 1 (G_1) is the pivot gun.

G_2P, G_3Q, G_4R are the zero lines of Nos. 2, 3 and 4 guns.

It is required to place the lines of Nos. 2, 3 and 4 guns at B, C and T_2, where B and C divide the target into three equal parts.
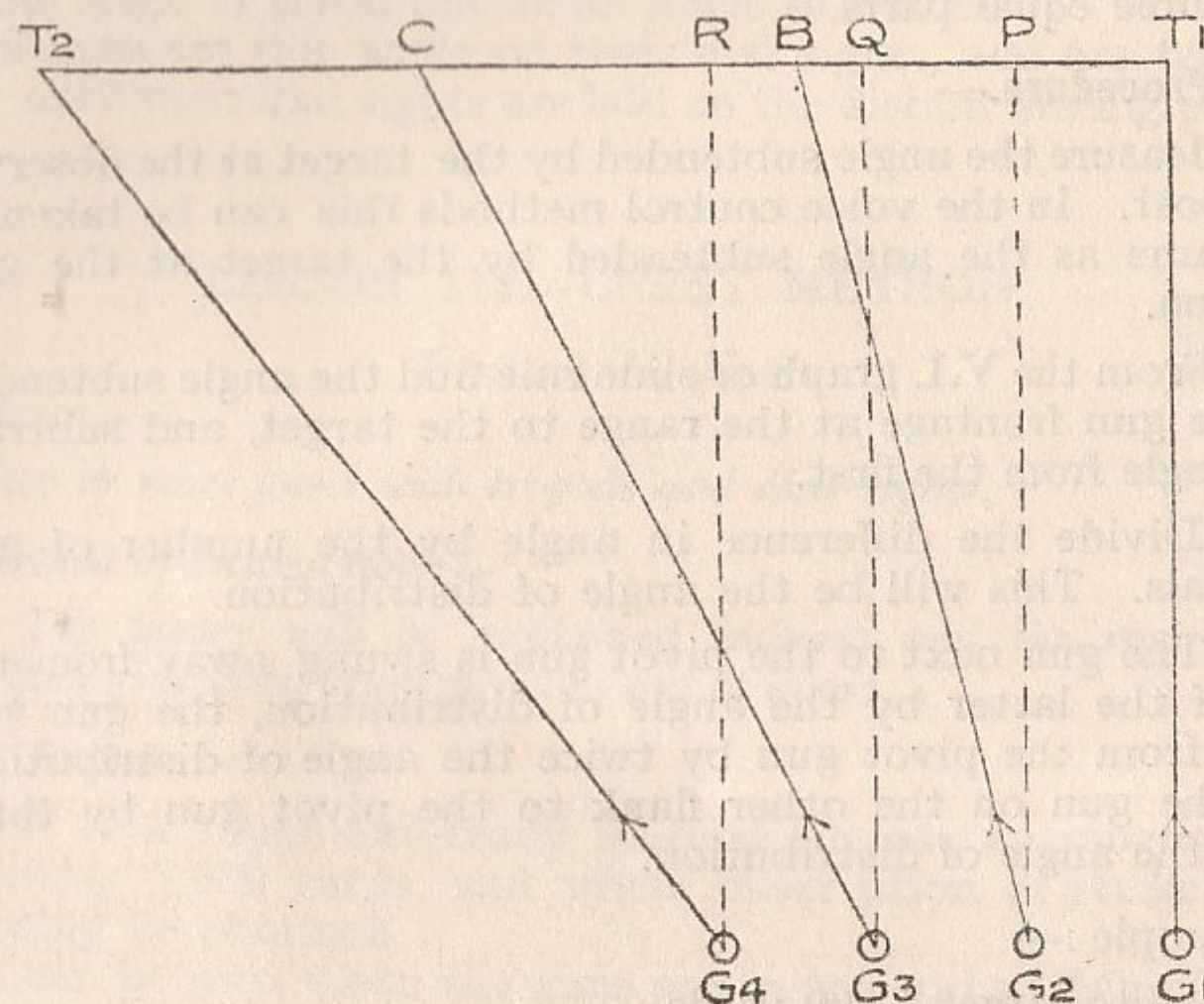

Fig. 26.

Now P is already one-third of the way along T_1R. If, therefore, we can switch No. 2 to B, where PB is equal to one-third of RT_2, B will be one-third along the whole distance T_1T_2.

Similarly for No. 3 gun, Q is already two-thirds of the way along T_1R; to place it at C, therefore, two-thirds of RT_2 must be added to T_1Q.

No. 4 gun must be moved to the left by the whole amount of RT_2 to bring it on to the left flank of the target.

In the procedure given, by subtracting the angular width of the gun frontage from the angular width of the target, we get the angular width of RT_2. This divided by three gives the angle of distribution.

4. It can be seen from Fig. 27 that when the lines of fire have been opened out only four points, T_1, B C and T_2 are struck by the beaten zones. It is necessary, therefore, to tap right and left so that the intervening spaces are engaged.
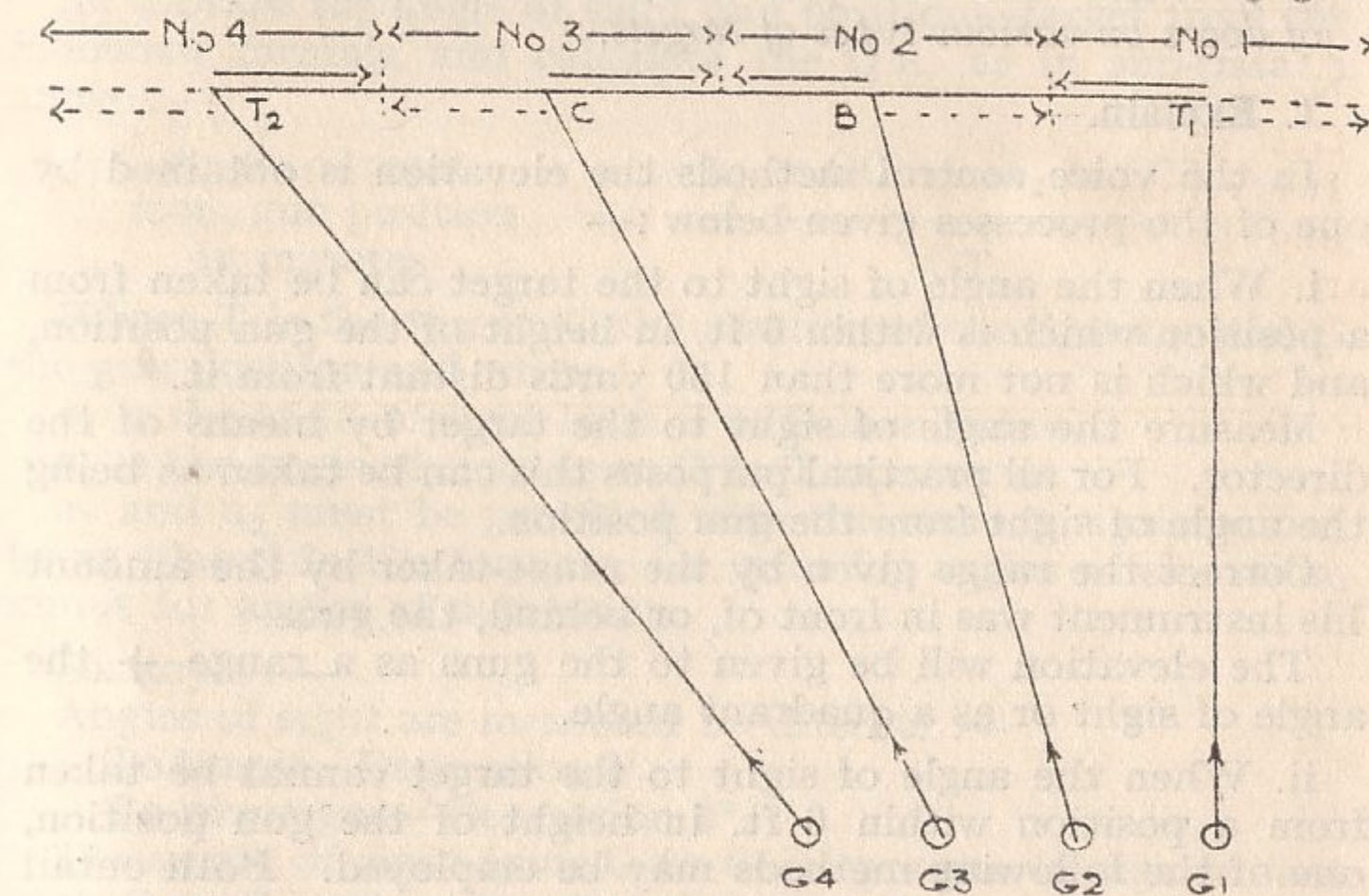
Fig. 27.

Each gun must tap right and left half one of the intervening spaces in order to cover the target. As these spaces are one-third of the target frontage, the rule for determining the amount of taps right and left is to divide the total angular frontage of the target by six. This is given to the guns to the nearest tap. As already stated, the flank guns traverse outside the flanks of the target to allow for errors in direction.

Since one gun cannot engage, with the best effect, more than about 50 yards of frontage, the width T_1T_2 should not exceed about 150 yards.

5. Targets with width greater than the gun frontage can be engaged either by opening out the lines of fire by means of distribution or by keeping the guns on parallel lines and switching them from one portion of the target to another. The method employed will depend on the nature of the target and the time available.

LESSON 114.—OBTAINING ELEVATION

Instructor's Notes

Stores :—

Blackboard, range tables, directors.

Method of Instruction :—

The procedure will be explained indoors. The squad will be practised with examples and the instruction completed out of doors on various types of targets.

1. Explain.—

In the voice control methods the elevation is obtained by one of the processes given below :—

i. When the angle of sight to the target can be taken from a position which is within 6 ft. in height of the gun position, and which is not more than 150 yards distant from it.

Measure the angle of sight to the target by means of the director. For all practical purposes this can be taken as being the angle of sight from the gun position.

Correct the range given by the range-taker by the amount his instrument was in front of, or behind, the guns.

The elevation will be given to the guns as a range + the angle of sight or as a quadrant angle.

ii. When the angle of sight to the target cannot be taken from a position within 6 ft. in height of the gun position, one of the following methods may be employed. Both entail measuring the angle of sight from the observation post to the target and to the gun position :—

(*a*) Using the range O.P. to target and the angle of sight to the target, obtain from the V.I. graph or slide rule the height the target is above or below the O.P.

Obtain the distance O.P.—gun position by pacing, or estimation, and, using the angle of sight to the gun position, obtain from the V.I. graph or slide rule the height the gun position is below or above the O.P.

A comparison of the heights of the gun position and target above or below the O.P. will give the height the target is above or below the gun position.

Convert this from the V.I. graph or slide rule to an angle of sight.

Example :—

Angle of sight from O.P. to target—Depression 22'.

Angle of sight from O.P. to gun position—Depression 2° 20'.

Range O.P.—target, 1,700 yards.

Distance O.P.—gun position, 80 yards.

Range gun position—target, 1,750 yards.

Target is below O.P.—11 yards. (The amount subtended by 22' at 1,700 yards.)

Gun position is below O.P.—3 yards. (The amount subtended by 2° 20' at 80 yards.)

Therefore target is below gun position 8 yards.

From V.I. graph or slide rule angle of sight (8 yards at 1,750 yards) = depression 15'.

(*b*) Obtain the angle of sight gun position—target from the following formula and calculate the Q.A. as in sub-para. i above :—

$$\text{Angle of sight from gun position in minutes} = \frac{(a_1 \times GO) + (a_2 \times OT)}{GT}$$

Where T is the target, O the position of the director and G the gun position and where

a_1 is the angle of sight from G to O in minutes.

a_2 is the angle of sight from O to T in minutes.

a_1 and a_2 must be provided with the correct signs before being placed in the formula, *i.e.*, plus for angles of elevation, minus for angles of depression.

Example :—

Angles of sight are measured by director :—

To target—Depression 5'.

To pivot gun—Depression 3°.

The angle of sight from G to O is opposite in sign to that from O to G, and is therefore elevation 3°.

OT = 1,900 yards, OG = 150 yards, GT = 2,000 yards.

The required angle of sight in minutes.

$$= \frac{180 \times 150 + (-5 \times 1,900)}{2,000}$$

$$= \frac{18 \times 15 - 5 \times 19}{20}$$

$$= \frac{270 - 95}{20} = + \frac{175}{20} = \text{approx. 9' elevation.}$$

Angle of sight = 9' elevation.

2. The target may have a different range to each end, and possibly also a different angle of sight. In this case the elevation must be calculated for each end of the target, which will give the elevations for the flank guns. The difference between these two elevations divided by three (the number

of gun intervals) will give the increase or decrease in elevation required between adjacent guns.

For example :—

No. 1 gun. Range 1,500 A. of S. +30'.
No. 4 gun. Range 1,350 A. of S. Nil.

The elevations for remaining guns will be :—

No. 2. Range 1,450. A. of S. +20'.
No. 3. Range 1,400. A. of S. +10'.

3. In the application of the combined sight principle to indirect fire, the fact that the guns are either on parallel lines or distributed means that they must all be given the same lifts (up or down) together.

Thus, when engaging a point target at 2,200 yards (range-finder) with an angle of sight from gun to target of plus 20' (no wind), the successive orders for elevation would be :—

Opening elevation .. All 2,200 +20' or All 4° 20'.
2nd   ,,   .. All down 50 or All down 10'.
                                    (The lift for 50
                                      at 2,200.)
3rd   ,,   .. All up 100 or All up 20'.
4th   ,,   .. All down 150 or All down 30'.
5th   ,,   .. All up 200 or All up 40'.

The " range and plus angle of sight " method of giving the elevation is preferable for point targets, and targets with width.

The " quadrant angle " method is preferable for targets with depth and area targets (see Sec. 30, Example 6).

LESSON 115.—CREST CLEARANCE

Instructor's Notes

Stores :—

Blackboard, range tables, director, gun and tripod with dial sight.

Method of instruction :—

The procedure will be explained indoors. The squad will be practised with examples and the instructions completed out of doors on various types of targets.

1. **Explain.—**

The initial responsibility for determining whether the bullets will clear the crest in front of the guns rests with the fire controller. He must ensure that, when he chooses the gun position, clearance exists for the target or targets he intends to engage.

It will not always be necessary or practicable to resort to measurement by instruments and calculation of crest clearance during the reconnaissance for the gun position. With practice it may often be possible to judge how far back the gun position can be situated without risk of the bullets striking the crest.

If, however, the range is short and the slope steep, it will be necessary to check the clearance as outlined below before the gun position is decided on and the guns are brought up.

The subsequent responsibility will rest with the N.C.O. in charge of the gun position. He must ensure that after the guns have been laid initially for direction and elevation, no gun is fired unless the bullets will clear.

Further, he must, at the first opportunity, ascertain the lowest quadrant angle at which the crest can be cleared and report it to the fire controller.

Calculations should always be made with reference to the highest point over which the guns may be called upon to fire.

The procedure for ascertaining the minimum quadrant angle either before or after the guns have occupied the position, and for checking whether the bullets will clear the crest after the guns have been given their initial line and elevation, is given below.

2. To ascertain the minimum quadrant angle.

Theory :

To ensure that the lowest shot of the cone clears the crest the following factors must be allowed for :—

i. The tangent angle for the range to the crest plus the possible error in determining the range.

ii. The height of the centre shot above the lowest shot.

iii. The angle of sight from the gun to the crest.

The sum of i and ii is known as the " Crest Clearance Angle " and is given for each range in the range table.

Procedure :

(a) Take the range from the gun position to the crest by range-finder. Look up the Crest Clearance angle for that range.

(b) Using the director at gun height or using one of the guns as decribed in Lesson 34, at the least favourable gun position, measure the angle of sight to the crest. The addition of the angle of sight to the crest clearance angle gives the minimum quadrant angle.

3. To ascertain, after the guns have been laid for elevation and direction, whether the crest will be cleared.

  i. Lay the guns at the lowest elevation required by the combined sight rule.

  ii. If the range to the crest is not more than 150 yards. Set the tangent sight at 400 yards. If the line of sight clears the crest, the bullets will clear.

  ii. If the range to the crest is more than 150 yards. Add 200 yards to the range to the crest. Place the resultant range on the tangent sight. If the line of sight clears the crest, the bullets will clear.

LESSON 116.—ANGLE OF SWITCH

Instructor's Notes

Stores :—

 Blackboard, one gun and tripod, dial sight, aiming post, directors.

 The subject matter will be given in the form of a lecture.

1. Explain.—

i. In each of the following diagrams :—

  G. = pivot gun or gun nearest to director.
  O. = Position of director.
  T. = 1st target.
  G.T. = Zero line on to 1st target.
  X. = Fresh target.

ii. It is not true to say that the angle of switch between T and X measured from O is for practical purposes equal to the angle of switch measured from G to bring G from GT to GX. The error may be so great that all four guns will miss the fresh target. The size of the error varies with the relationship of T.O.G. and X to one another.

In every case it is necessary to find the angle TGK as accurately as possible.

(*a*) In very rare conditions it may be possible with a director mounted in the gun position to measure the angle TGX which obviously will be the same as the angle TOX.

(*b*) Sometimes O may be within the zero lines of the guns, either in front or behind.

From O measure angle TOX, convert that angle to yards at range OX. Convert those yards back to angle for GX. The answer will be angle TGX (angle of switch for G from T to X).

 e.g. Angle TOX = 8° at OX 1,500 x = 210 x
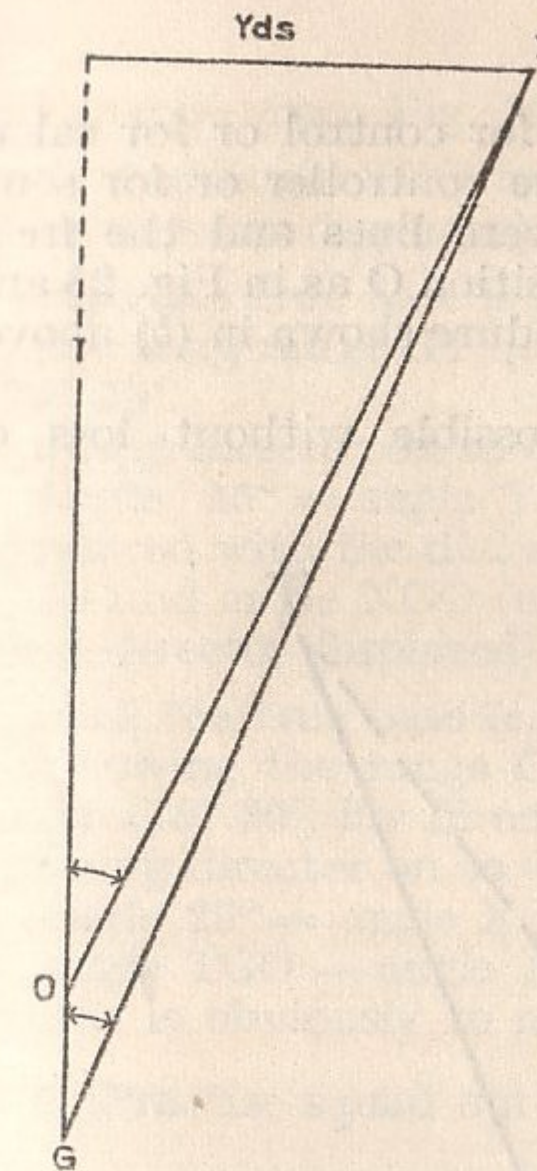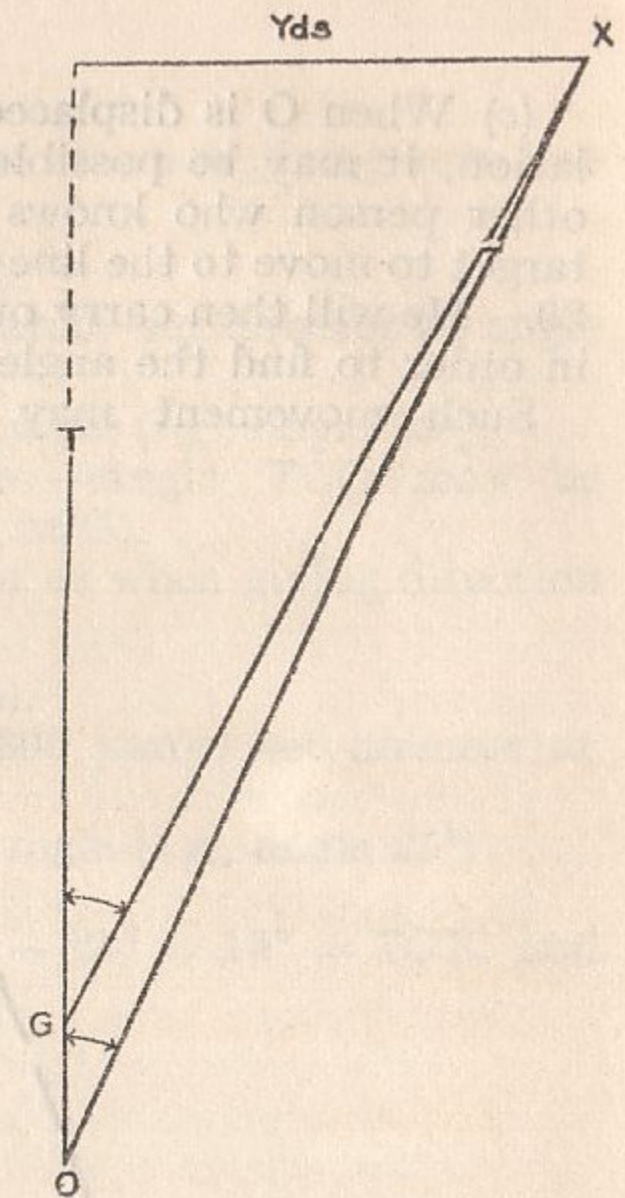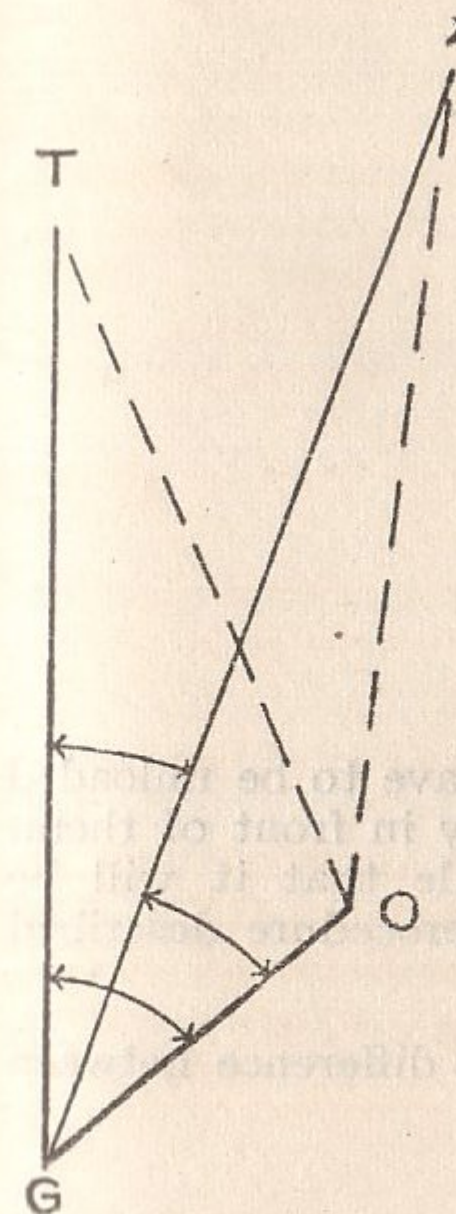 210 at GX 1,600 = 7° 30′ = angle TGX.

Fig. 28.

Fig. 29.

Fig. 30.
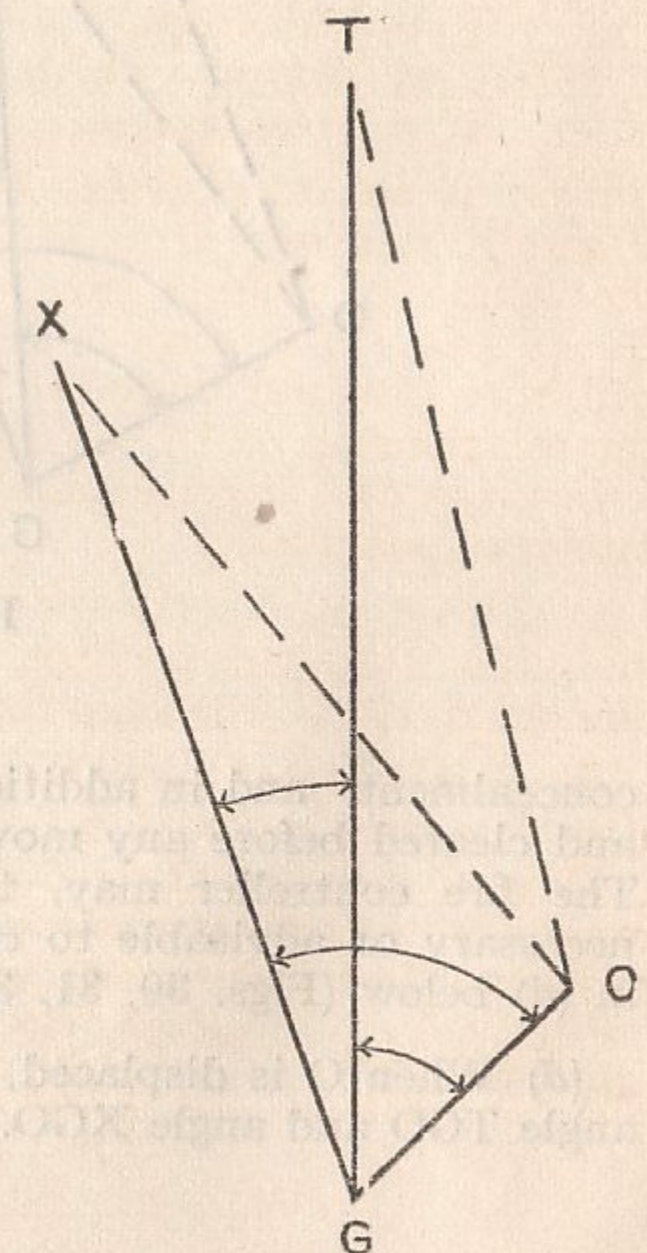
Fig. 31.

(c) When O is displaced, whether for control or for calculation, it may be possible for the fire controller or for some other person who knows both the zero lines and the fresh target to move to the line GT to a position O as in Fig. 28 and 29. He will then carry out the procedure shown in (b) above, in order to find the angle TGX.

Such movement may not be possible without loss of
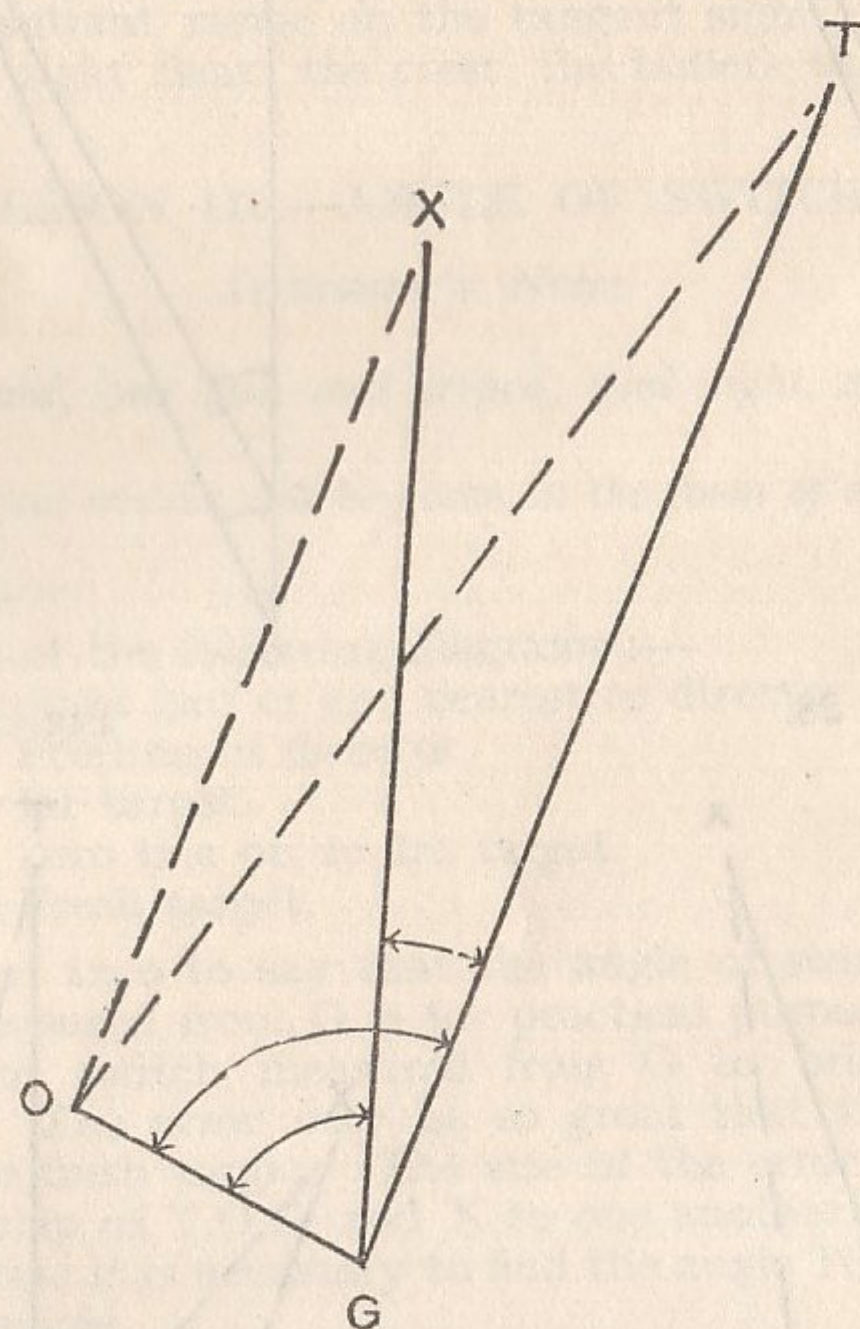
Fig. 32.

concealment, and in addition guns will have to be unloaded and cleared before any movement directly in front of them. The fire controller may, therefore, decide that it will be necessary or advisable to carry out the procedure described in (d) below (Figs. 30, 31, 32) :—

(d) When O is displaced, angle TGX = difference between angle TGO and angle XGO.

Example from Fig. 30.

To find angle TGO (using director as when giving zero line from director displaced) :—

Find the true base (e.g., 96 yards).

Knowing range GT (e.g., 1,500 yards) set director at angle 176° 20′.

Swing director on to G and read angle (e.g., angle 35°).

Angle 35° = angle TGO. (Note :—Angle TGO may be measured with the dial sight of gun at G).

To find angle XGO (using director as when giving direction from director displaced) :—

Find the true base (e.g., 43 yards).

Knowing the range GK (e.g., 1,800 yards) set director at angle 178° 30′, lay director on X.

Swing director on to G and read angle (e.g., angle 25°).

Angle 25° = angle XGO.

Angle TGO — angle XGO = 35° — 25° = 10° = TGX and switch is obviously to right.

2. Practise squad out of doors.

SECTION 26.—NIGHT FIRING

1. This section contains the arrangements to be made for engaging a target at night. It should be noted that these arrangements can be applied to conditions of bad visibility such as fog, dust or smoke.

2. The simplest method of night firing is when the guns can be brought into position by day, laid, and aiming posts planted. If more than one target is to be engaged, it would be necessary to place the guns on zero lines. At dusk, aiming lamps will be put out. (*See* Lesson 71.)

If the target is not visible from the gun position, indirect means must be employed to lay the guns.

3. Before darkness falls, all data required to enable the various targets to be engaged must be obtained.

These include some or all of the following :—

The angles of sight and ranges to the various targets.
The angular width of the targets.
The angles of switch.
Data affecting any existing or possible safety problem.
It is essential that the magnetic bearing of the zero line should be recorded as a check.

4. When firing is carried out from positions behind the forward localities, special precautions, such as posting sentries or wiring the danger area, must be taken to ensure the safety of our own troops when passing near the gun positions.

LESSON 117.—RECONNAISSANCE BY DAY (ONE TARGET ONLY).

Instructor's Notes

Stores :—

Gun pegs, direction pegs, zero posts and directors.

Method of instruction :—

A simple tactical situation will be defined and the procedure explained. The squad will practise putting out pegs both in front and in rear of the gun position.

1. Mark the position of each gun by a small post (gun peg).

Place a second post (direction peg) for each gun in direct alignment of the gun peg and the position on the target for the gun concerned.

Place a zero post accurately in line with and between the gun peg and direction peg.

Both direction peg and zero post can be put in either by using a director or by eye.

The direction peg should be about 30 yards from the gun peg and the zero post in such a position that it will be silhouetted against a lamp, held behind the direction peg.

To avoid exposing personnel in front of the gun position, it may often be desirable to place the direction pegs and zero posts in rear of the gun pegs. In this case it may be necessary to screen the aiming lamps from the front when giving direction to the guns.

2. When the guns are brought up the procedure is as described in section drill—night firing (Sec. 19).

LESSON 118.—RECONNAISSANCE BY DAY (TWO OR MORE TARGETS).

Instructor's Notes

Stores :—

As for Lesson 117, with the addition of slide rules and range tables.

Method of instruction :—

The instruction will be developed from Lesson 117, so as to include placing guns on parallel zero lines.

Explain.—

Here it is necessary to put out gun direction pegs and zero posts for each gun on parallel zero lines, so that the guns can be switched. The direction pegs and zero posts may be in front of or behind the gun pegs.

Gun pegs are put out for each gun. A zero line is selected and a direction peg and zero post for the pivot gun aligned on it.

Where a distant aiming point is available (Lesson 111) with a director measure the angle between the distant aiming point and the zero line for the pivot gun. Mount the director in turn over the remaining gun pegs, lay this angle off the aiming point and place the direction peg and zero post in this line.

Where no distant aiming point is available, the following method may be adopted. The procedure is described for two guns only, but can be extended to include four guns if required.

Put out gun pegs for each gun (G_1G_2) (Fig. 33).

Place a direction peg (P_1) and zero post (Z_1) on the zero line for the pivot gun, either in front of or behind the gun position.

v. When both guns in the relieving section are laid for direction, this aiming lamp will be removed. The relieving section will then put out its own aiming lamp, the further procedure being as in section drill. (Night firing (Sec. **19**).)

LESSON 121.—WHEN THE GUN POSITION CANNOT BE REACHED BY DAY

Instructor's Notes

Stores :—

Compass, gun and direction pegs, zero posts, one (or more) guns, tripods and dial sights.

Method of instruction :—

The class will practise laying out compass lines from gun pegs The measuring of direction and elevation from the map should. not be practised until Lesson 122 is reached. The class will then practise as in (ii).

Explain.—

i. When a map is available.

The true (or grid) bearing from the pivot gun to the target or zero line is measured from the map and converted to compass bearing ; using a compass, gun pegs, direction pegs and zero posts for each gun are put out on this bearing (Lesson **122**). The guns are then mounted over the gun pegs.

If desired, a gun peg, direction peg, and zero post for the pivot gun only can be put out by means of the compass. The guns are mounted, the pivot gun being mounted over its gun peg and given direction. The remaining guns are then placed on parallel lines by the post method (Lesson **110**). The point of aim for each gun must be illuminated.

When using either of the above methods great accuracy cannot be expected.

ii. When no map is available.

If circumstances allow of a light being shown on the spot where it is desired that the fire should fall, arrangements can be made to fire on a fixed line at short range with fair accuracy.

The procedure is described in Lesson **132**.

SECTION 27.—MAP SHOOTING

1. Accurate shooting from the map is only possible when a map scale 1/25,000 or larger is available. Where accuracy is not essential, for example, for the engagement of areas well removed from the position of our own troops, maps of smaller scale should not be ignored, but it should be noted that the detail on such maps is not usually "surveyed in."

2. The principle of map shooting is that all calculations, both for direction and elevation, are made from the map. The method has certain definite advantages, namely :—

   i. No observation post is necessary.
   ii. Preparations to open fire can be made before the actual targets have been located.
   iii. Targets can be engaged which cannot be seen by ground observation.

3. The method entails fixing the position of the pivot gun on the map, and by various means laying out a zero line for each gun. These processes must be carried out in daylight, though the guns themselves need not be brought into action until after dark. Therefore orders for a map shoot to be carried out at night must reach the platoons concerned in sufficient time before dark.

4. The pivot gun can be fixed on the map either :—
   i. By comparing the detail on the ground with the detail on the map ; or, if this is not possible :
   ii. By resection (*see Manual of Map Reading, Photo Reading and Field Sketching, 1929, Sec. 56*).

Where time permits, greater accuracy is ensured by employing one method and checking with another.

It may be possible to obtain the aid of a survey unit where a very accurate location is necessary.

Oblique air photographs may be helpful.

LESSON 122.—SHOOTING FROM THE MAP

Instructor's Notes

Stores :—

Map (minimum scale 1/25,000), protractor, compass, gun and direction pegs, zero posts, director.

Method of instruction :—

The class will be instructed in measuring angles and bearings on the map and will then work out problems of

elevation and distribution. Indoor work should conclude with the construction of a fighting map (Plate 27, p. 76) on which problems should be set. The class will practise out of doors the locating of the pivot gun both by local detail and resection.

Explain.—

i. *Direction.*

A zero line is chosen in the centre of the target area, or, if the targets are not known, in the most suitable direction.
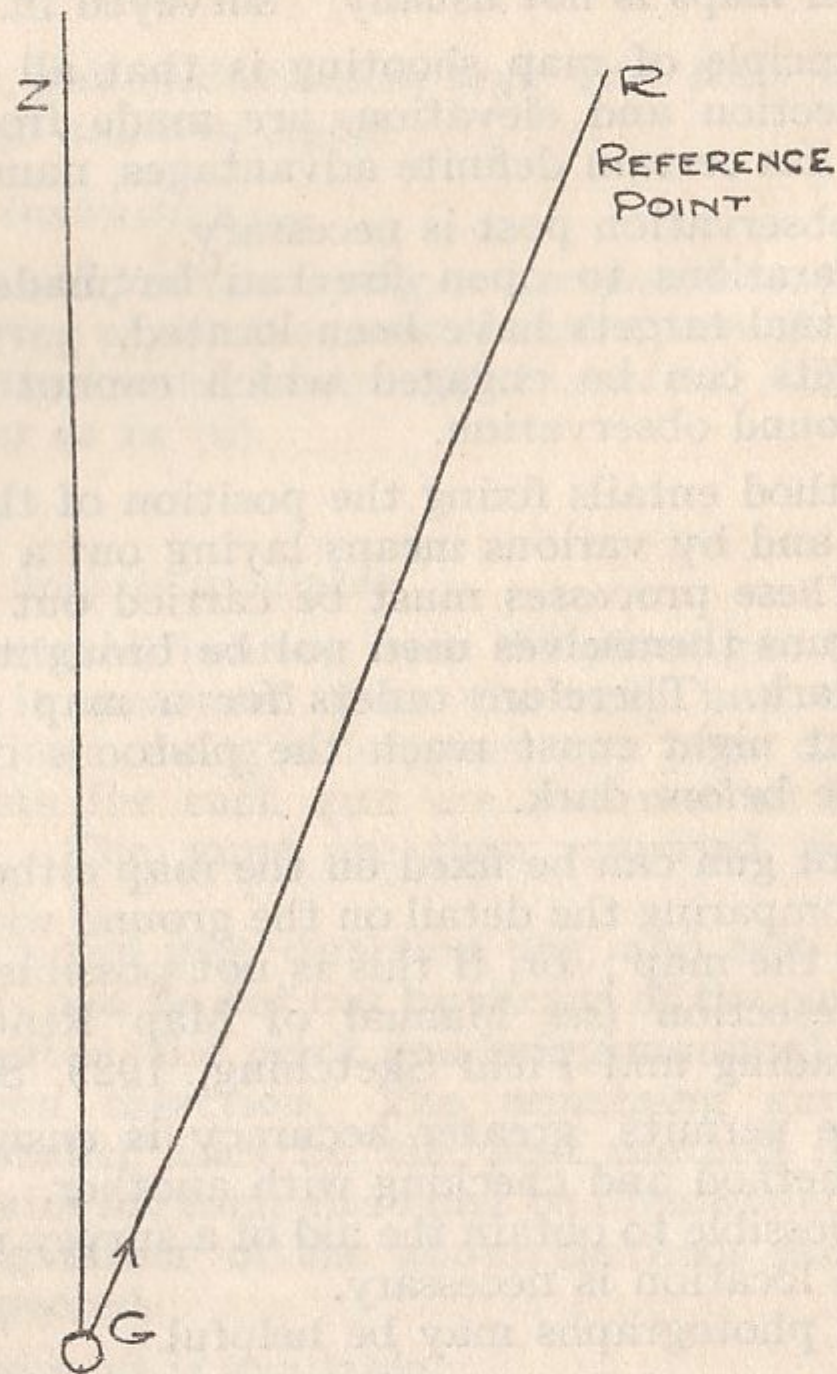
Fig. 34.

Two methods may be employed for placing the guns on their zero lines :—

(a) By means of a reference point.
(b) By compass.

    (a) By reference point.

A reference point which is both marked on the map and visible from the pivot gun is selected. (*See* Fig. 34.)

The zero line of the pivot gun is drawn on the map (GZ).

The line joining the pivot gun to the reference point is also drawn in (GR).

The angle RGZ is measured with a protractor.

If the guns are in position :—

This angle is set on the dial sight of the pivot gun, which is then tapped over until the dial sight is laid on the reference point.

The remaining guns are placed parallel to it by the most suitable method.

If the guns are not in position :—

Mark the point G with a gun peg.

Mount a director centrally over it and swing through the angle RGZ.

Place a direction peg and zero post on the line GZ a suitable distance from the gun peg.

Mark the positions for the remaining three guns with gun pegs.

Place direction pegs and zero posts for each gun on lines parallel to GZ, by any of the methods described in Lessons 108, 110.

    (b) By compass.

The magnetic bearing of the target from the pivot gun must be found.

To do this—

Draw a line on the map along the zero line of the pivot gun.

Using the protractor, measure the bearing this line makes with a grid north and south line.

This is the grid bearing of the zero line of the pivot gun.

Add the magnetic variation of the compass from grid north.

The result is the magnetic bearing of the zero line from the pivot gun. This applies to places where the magnetic variation is west. If the variation is east, subtract instead of add.

The variation of any compass used must be determined for the particular locality, and should be constantly checked.

To lay the pivot gun on the magnetic bearing so obtained.

Place a post in the gun position, and place the compass on the top of the post. Rotate the compass until the card reads the required bearing.

Align a direction post on this bearing, using the hair line on the compass.

Proceed as described under the reference point method above, according to whether the guns are in position or not.

PLATE 27.

see Lesson 122 (V)

Fighting Map – Platoon.

TE A. of S. for 10 metres.

17° —
16° —
15° — 9'
14° —
13° —
12° — 10'
11° —
10° — 11'
9° —
8° — 12'
7° — 13'
6° — 14'
5° — 15'
16'
17'
4° — 18'
19'
3° — 20'
21'
22'
23'
24'
2° — 25'
27'
29'
31'
34'
1° — 38'
TE A. of S. for 10 metres.

Range 4500, 44, 43, 42, 41, 4000, 39, 38, 37, 36, 3500, 34, 33, 32, 31, 3000, 29, 28, 27, 26, 2500, 24, 23, 22, 21, 2000, 19, 18, 17, 16, 1500, 14, 13, 12, 11, 1000

15°, 10°, 5°, 0°, 5°, 10°, 15°

Number of Gun..........
Number of Pivot Gun......
Location of Pivot Gun–
Compass bearing of Zero Line............

Ref. Map..............

Date....... Pltn. Cmdr.

Scale 1/20,000

---

ii. *Distribution.*

On the map, join the pivot gun to the two ends of the target. Measure with a protractor the angle thus formed at the pivot gun. Taking this as the angular width of the target, proceed as in Lesson 113.

iii. *Elevation.*

On the map, measure the range to the target and note :—

(a) Gun contour.
(b) Target contour.

Using the height the target is above or below the gun, find the QA from the QA graph. If the latter is not available the angle of sight can be calculated from the VI table or slide rule and the elevation determined in the normal manner.

iv. *Crest clearance.*

It may be necessary to ascertain whether the bullets will clear an obstruction which is not visible from the gun position. The procedure will be as follows :—

Measure the range to the crest.

From the contours determine the height the obstruction is above the gun position. Add to this the lower half of the cone at the range to the crest.

Turn to the QA graph in the range table and see whether the curve for the QA which is being used clears the above height at the range to the crest.

v. *Fighting map.*

When a position is to be occupied for some time, and maps of sufficiently large scale for accurate shooting are available, steps should be taken to prepare a fighting map, so that new targets can be engaged in the minimum time. This entails either drawing on the map itself or on tracing paper a combination of degree and range scales in the form of that shown on Plate 27.

The centre of the circle at the bottom is placed at the position of the pivot gun, and the line marked 0° at the top placed along the zero line. A thread is attached to a pin and stuck in the position of the pivot gun.

When the co-ordinates of a target are received they are plotted in the map, and by means of the thread the angle of switch from zero can be read off. The tangent angle is then noted and the angle of sight calculated.

SECTION 28.—THE T.O.G. METHOD

If voice control methods are not possible and a suitable map does not exist, the T.O.G. method can be used, provided that an observation post can be found from which both the pivot gun and the target can be seen. The distance of the observation post from the gun line is not limited.

The method is deliberate, owing to the distance involved. Unless a telephone is provided, its uses are confined to programme shoots such as barrages, neutralization in support of prearranged attack, etc.

LESSON 123.—T.O.G.

Instructor's Notes

Stores :—

Plotter, range-tables, directors, two or more guns with tripods and dial sights, aiming posts.

Method of instruction :—

The situation necessitating the use of T.O.G. and its limitations will be explained. The class will then practise its application outside on the ground.

1. Explain.—

i. A target with width equal to or less than the gun frontage.
The ranges OG_1 and OT_1 are taken by the range-taker. (Fig. 35.)

The angle T_1OG_1 is measured with the director.

The angles of sight to G_1 and T_1 are taken.

The angle OG_1T_1 and the range G_1T_1 are obtained from the plotter. (*See* Lesson 41.)

The angle of switch OG_1T_1 and the elevation are sent by orderly or taken down to the guns, together with orders when to open fire.

At the guns.

The guns are mounted roughly in the direction of the target. On receipt of the angle OG_1T_1 this angle is put on the dial sight of the pivot gun, which is then laid on the director as taught in Lesson 79.

The pivot gun is then used to put the remaining guns on parallel zero lines as in the post method.

To switch to a new target (x) and find the angle OG_1X by means of the field plotter. The difference between the angles OG_1X and OG_1T_1 is the angle of switch for the pivot gun to the new target.

ii. A target wider than the gun frontage.
It will be necessary to determine the angular width of the target from the gun position.

G1 PIVOT GUN
T1 RIGHT END OF TARGET

G4 G3 G2 G1
Fig. 35.

The range-taker takes the range OT_2 (Fig. 36) in addition to those taken as in sub-para. 1.
The angle T_2OG_1 is measured.

T1 T2 IS THE TARGET.

Fig. 36.

The range G_1T_2 and the angle T_2G_1O are obtained from the plotter.

The angle OG_1T_1 has already been obtained, and it can be seen that the angular width of the target from the gun position $T_1G_1T_2 = T_2G_1O - T_1G_1O$.

The angle of distribution can then be calculated in the normal manner. (Lesson 113.)

If T_2 is at a different range or has a different angle of sight to T_1, it will be necessary to calculate the quadrant elevation for each gun as is Lesson 114.

2. Crest clearance.

If there is a crest X (Fig. 37), invisible from the guns, and there is a doubt as to whether the bullets will clear, the procedure is as follows:—

Measure the angle XOG_1, and angle of sight from O to X.

Obtain from range-taker range OX.

As before, solve the triangle XOG_1 to obtain G_1X and angle OG_1X. By comparison of the angles OG_1X, OG_1T_1 and OG_1T_2, it can be determined whether the obstruction is in the line of fire.

Fig. 37.

If this is the case, ascertain the corrected angle of sight from G to X (Lesson 114) and work out the minimum quadrant angle (Lesson 115) to clear X. Compare this angle with the lowest quadrant angle used to engage $T_1 - T_2$.

3. A specimen form to simplify the booking of the data and the subsequent calculations is given below. The data obtained by measurement is underlined. In practice, all data should be obtained before calculation is commenced.

	Yards	Min.			Distribution
			above	G	G
			below		G
			above	T_1	G
			below		
			above	T_2	
			below		
			above	X	
			below		
OG	=			Angle of sight O to G	=	A of S
OT_1	=			Angle of sight O to T_1	=	
OT_2	=			Angle of sight O to T_2	=	
OX	=			Angle of sight O to X	=	
Wind					

	Yards	Min.	Range		
			T_1OG	G1	Divided by 3 = Angle of distribution
			T_2OG	G2	
			XOG	G3	
				G4	

	Yards	Min.	Difference		
GT_1	=	above G	T_1 above		
		below G	T_1 below		
GT_2	=	above G	T_2 above		Minimum QA
		below G	T_2 below		
Angle of switch for T_1				X above G	
Angle of switch for T_2				X below G	
Width of target (difference =				XGO =	
Width of gun frontage				GX =	

SECTION 29.—FIRE DIRECTION AND CONTROL CHARTS

1. For the conduct of programme shoots, when fire is required at varying periods on one or more targets, it will generally be preferable to issue charts for the direction and control of fire. This will usually apply to shooting off the map and the firing by night ; for example, in the provision of covering fire for a dawn attack, harassing fire, counter-preparations, barrages, etc.

2. **Fire direction charts** will be prepared by the M.G. company commander, with the object of allotting tasks to individual platoons, or, occasionally, sections. A suitable form is shown on page 85.

Time must be allowed in the programme for the lifts and switches to be put on the guns. At night, a pause of 20 seconds should be allowed for each lift and 30 seconds for each switch. When tapping right and left is required, the time taken to complete the series of bursts and taps should also be allowed for.
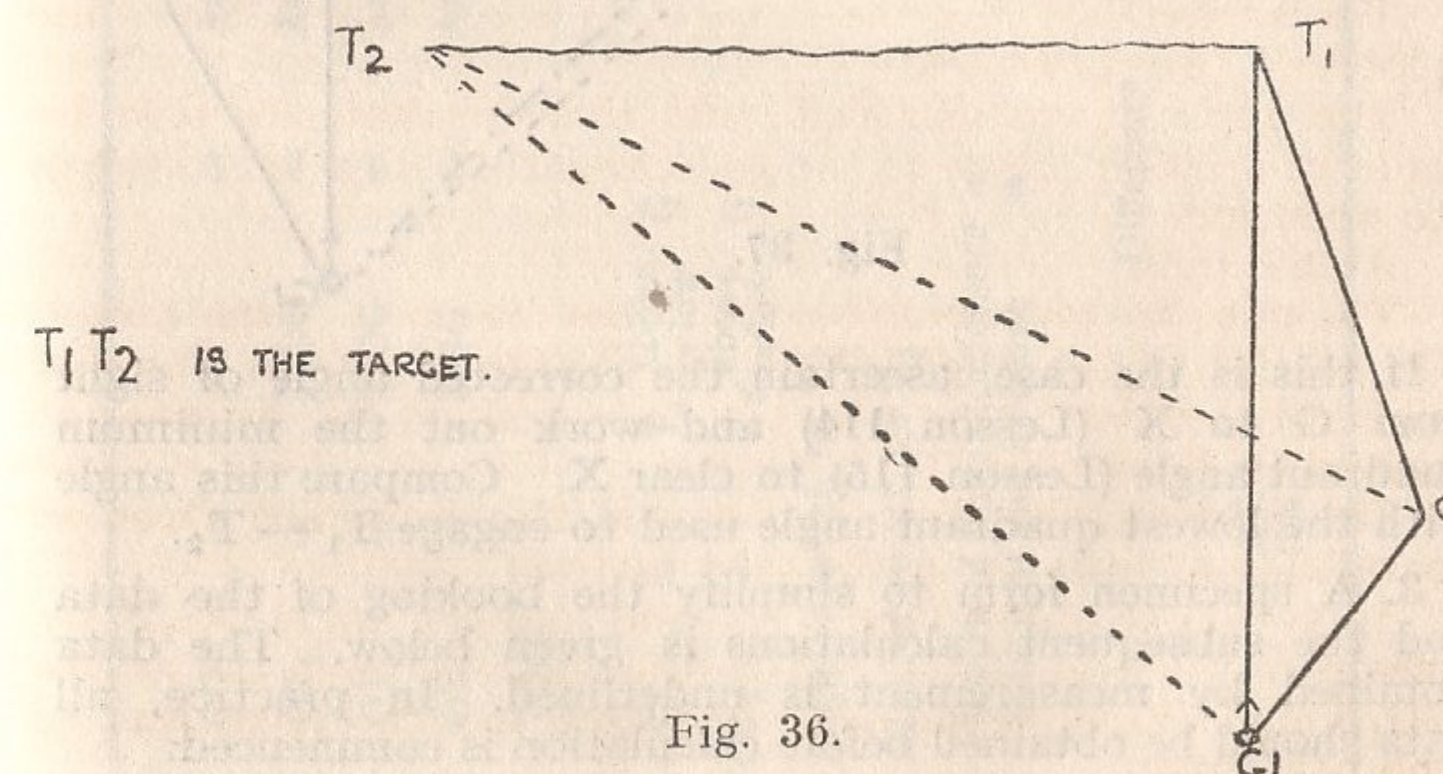
In prolonged programmes, pauses should be allowed for the maintenance of the guns. The pauses should be so arranged that never more than one gun at a time is stopped for this purpose.

3. **Fire control charts** are made up by platoon commanders, one for each gun, and are interpreted by a N.C.O. at each gun. They are prepared from data obtained from the fire direction chart, if issued, and by measurement.

The chart contains the actual detail of switches, timing and rates of fire, and the elevation and number of taps right and left to be employed for each target. A suitable form is shown on page 86.

When firing indirect by day, it will often be advantageous to prepare a simplified form of chart for use at the guns.

LESSON 124.—PREPARATION OF CHARTS

Instructor's Notes

Stores :—
   Map (1/25,000 or larger scale).

Method of instruction :—
   Officers will be instructed in the preparation of both types of chart, both from detail on the map (indoor work) and from

reconnaissances on the ground (outdoor work). N.C.Os. will study only the preparation of fire control charts. They will be given the fire direction chart and instructed in compiling the fire control chart—both from detail on the map and on the ground.

1. **Explain.—**

The angle of deviation from zero of any target is the actual deflection from the zero line to bring the gun on to its correct position on that target. In the case of a platoon, it is formed by combining the angle of switch with the angle of distribution, if any, or its correct multiple. (*See* Fig. 38.)

In the case of a section, it is formed by combining the angle of switch from zero lines with the angle necessary to bring each gun a quarter of the way in from its own flank of the target.

When dealing with targets with width equal to or less than the gun frontage, guns are kept on parallel lines.
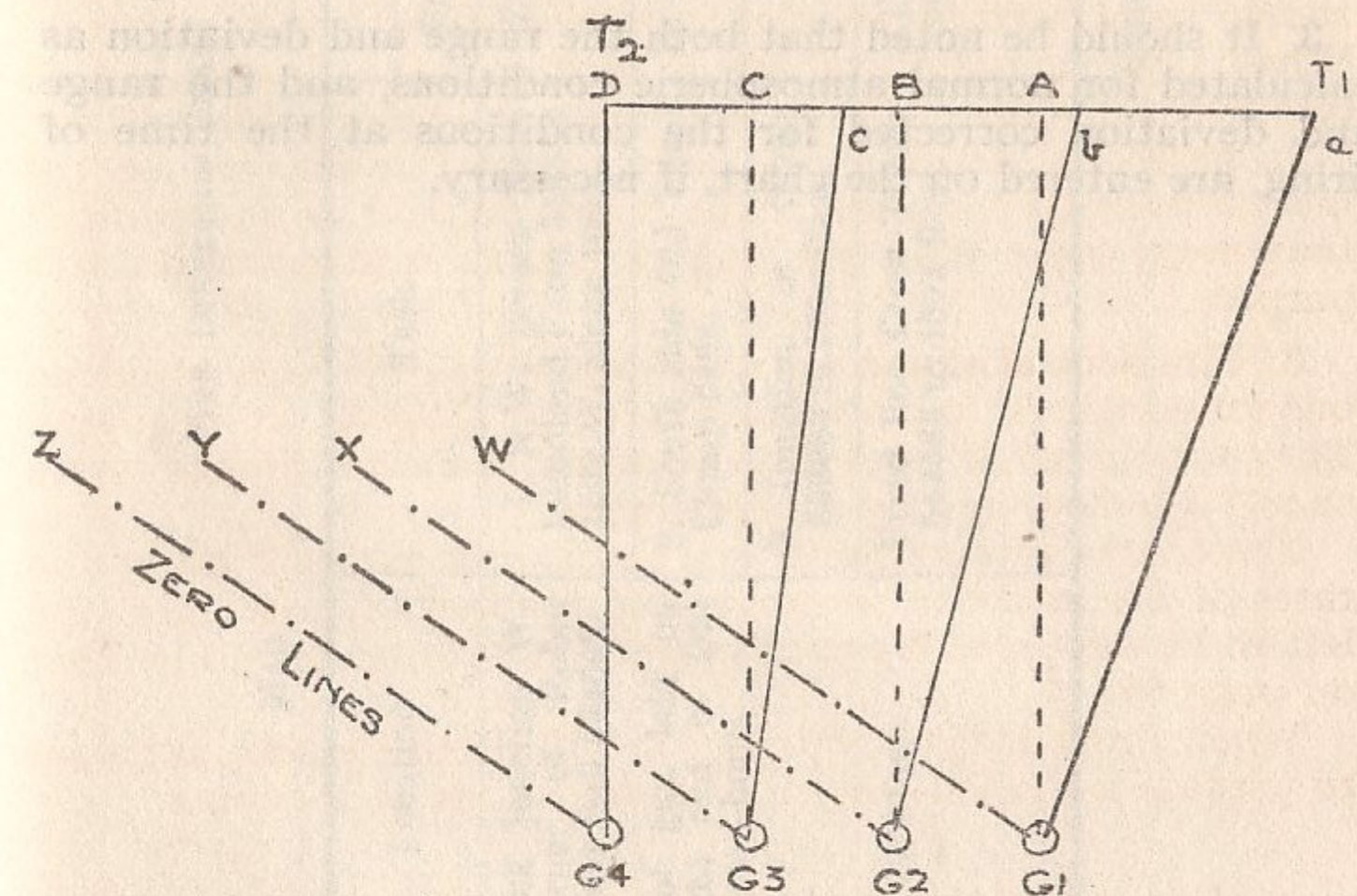

Fig. 38.

Angle ZG_4T_2 = Angle of switch.

CG_3c =	,,	distribution.
cG_3Y =	,,	deviation from zero, No. 3 gun.
bG_2X =	,,	,, ,, ,, No. 2 gun.
aG_1W =	,,	,, ,, ,, No. 1 gun.

Example.—

The angle of switch for a certain target is Right 11°, the angle of distribution is 30 minutes. No. 4 is the pivot gun. It is required to find the angle of deviation from zero for No. 1 gun.

No. 1 gun has to be swung to the right through the angle of switch—Right 11°, and also (still in the same direction) through three times the angle of distribution $=3 \times 30' = 1° 30'$; the angle of deviation from zero is therefore Right 12° 30' for this particular gun and target.

If the switch had been *left* 11°, the angle of deviation from zero would have been Left 9° 30'.

2. When zero lines are laid out before the targets have been decided, it may occur that the zero line originally chosen is not the most suitable for the targets. In this case the zero line should be corrected by an angle of switch to a new and suitable zero line, and the fire control chart made out with reference to the letter.

3. It should be noted that both the range and deviation as calculated for normal atmospheric conditions, and the range and deviation corrected for the conditions at the time of firing, are entered on the chart, if necessary.

FIRE DIRECTION CHART

Date

Map

Ref.	Unit and Role	Location	Task	Times From	Times To	Rate of fire. Remarks.
	No. 7 Platoon ..	Track junction W. Corner of Robin Hood Ball 544666.	1. N.W. corner New-foundland Farm 5468 to 150x W. along track.	Zero	Z + 4.	Rapid.
		Pivot gun laid on right end of Old Farm Clump.	2. South side Old Farm Clump 5468.	Z + 5	Z + 10	Normal.
			3. Junction of tracks 539683 to 150x East.	Z + 12	Z + 19	Normal.
		45x Frontage.	Fixed line Cross Tracks 542685 to 150x East.	S.D.F. Red, green red.		2 min. Rapid. 3 min. Normal.

Signed, F. J. Blank, Capt.,

Commanding A Coy.

FIRE CONTROL CHART

No. 7 PLATOON ROLE.

No. 4 Gun.
Magnetic bearing of zero line 3°.

N.C.O. i/c Gun—Corpl. Round.
Angle of switch to corrected zero lines—Nil.

Task	Clock Time From	Clock Time To	Zero Time From	Zero Time To	Angle of Deviation from Zero.	Normal Range or Q.A.	Angle of Sight.	Corrected Elevation or Deviation	Right and Left Taps.	Rate of Fire.	Remarks.
1.			Z	Z + 4	R.7° 10'	1750x Down 50x Up 100x	−40'		3	Rapid.	
2.			Z + 5	Z + 10	L.1° 20'	2150 Down 50 Up 100 Down 150 Up 200	−25'		1	Normal	
3.			Z + 12	Z + 19	L.13° 30'	1950 Down 50 Up 100	−20'		3	Normal	
S.D.F. Red, Green, Red. Fixed Line					R.2° 50'	2100	−15'		Nil	2 min. Rapid. 3 min. Normal.	

Signed, G. Smith, P.S.M.
Commanding No. 7 Platoon.
Date................

LESSON 125.—BARRAGES

Instructor's Notes

Stores :—

Blackboard or sand-table, map (1/25,000 or larger scale), protractor. range-tables.

This lesson should only be taught to officers, W.Os and N.C.Os, who are training to become platoon commanders.

1. Explain.—

i. When a large number of guns and sufficient ammunition are available, machine guns may be used for barrage fire. Machine gun barrages will usually be required as part of a fire plan which includes the fire of artillery and, possibly, mortars.

Except where the ground is favourable for safety reasons overhead fire must be at least 400 yards ahead of the advancing troops. Unlike artillery support, when the infantry can see the fall of the shells, the infantry have no means of knowing how close they are to a machine gun barrage. For these reasons, when an attack without tanks is being supported, machine guns should be used for the neutralization of targets in depth or on the flanks, the closer barrage being fired by some of the artillery.

ii. There are two types of barrage :—

i. Creeping barrages. In which the barrage moves forward in accordance with a prearranged programme at a rate at which the attacking troops can keep up with it. The line on which the barrage opens, and the lifts, are worked out having regard to safety considerations.

ii. Standing barrage. Put down on a definite line and remaining there as long as required or safety considerations permit. Standing barrages may be used either in support of an attack, or, in the form of a box barrage, in order to isolate any area of ground to prevent reinforcement or counter-attack during a raid or small attack operations.

iii. Barrages can be either frontal, oblique, or flanking. The frontal creeping barrage is easier to calculate and control. The flanking barrage may be put down much closer to our own troops than a frontal barrage, but it will seldom be possible to find gun positions which give complete enfilade.

Oblique barrages have the advantages and disadvantages of the frontal and flanking types according to the degree of obliquity.

iv. The intensity of a barrage depends on the range, and the slope of the ground in relation to the angle of descent of the bullet. As a rough guide, for a frontal barrage, at least one gun per 30 yards of front will be needed.

v. Standing flanking barrages should consist of two parallel lines of fire about 60 yards apart.

vi. The preparations for a barrage sheet are similar to those described in Sec. 29, paragraphs 1-3.

2. Practice.—

Give examples on the blackboard, map or sand-table of various types of barrages, and discuss the number and siting of guns, and the preparation of fire control charts.

SECTION 30.—EXAMPLES OF INDIRECT FIRE ORDERS

1. Point target, or target not wider than gun frontage. Range obtained by range-finder 1,600 yards. Angle of sight plus 30'. Wind 30 m.p.h. 6 o'c. Director method.

Fire controller.	N.C.O. i/c gun position.
Zero lines.	
No. 1—Right—Two one degrees one owe minutes.	
No. 2—Right—Nine degrees.	
No. 3—Left—Seven degrees four owe minutes.	
No. 4—Left—One nine degrees.	
All—sixteen hundred plus two five minutes.	
	Reports " Guns ready to load."
Load.	
Right and left—One tap.	
Rapid fire.	
Stop.	
All down—fifty.	
Go on.	
Stop.	
All up one hundred.	
Go on.	

2. Target with width.

Range obtained by range-finder. 1,400 yards. Target width—6°. Angle of sight plus 50'. Wind 20 m.p.h. 1 o'c. Post method. No. 1 Gun.—Pivot gun.

Fire controller.	N.C.O. i/c gun position.
	Zero lines.
	No. 4—Left—Eight seven degrees two owe minutes.
	No. 3—Left—Eight four degrees.
	No. 2—Left—Eight two degrees five owe minutes.
	Reports—" Guns on zero lines."
All—Fourteen hundred plus five five minutes.	
	Reports " Guns ready to load."

Load.
Distribution.
No. 1—Nil.
No. 2—Left—One degree two owe minutes.
No. 3—Left—Two degrees five owe minutes.
No. 4—Left—Four degrees one owe minutes.
Right and Left—Four taps.
Wind—Right two owe minutes.
Fire.

3. Oblique target having the same range to each end, by range-finder. Range 1,750 yards. Angle of sight to right end plus 30′, to left end nil.
  Angular width 1° (less than gun frontage).
  Wind—nil.
  Director method.

Fire controller.	N.C.O. i/c gun position.
Zero lines.	
No. 1—Right—Two two degrees one owe minutes.	
No. 2—Right—One owe degrees.	
No. 3—Left—Six degrees four owe minutes.	
No. 4—Left—One eight degrees.	
All—Seventeen fifty.	
No. 1—Plus three owe minutes.	
No. 2—Plus two owe minutes.	
No. 3—Plus one owe minutes.	
No. 4—Nil.	
Load.	Reports '' Guns ready to load.''
Right and Left one tap.	
Rapid fire.	
Stop.	
All down fifty.	
Go on.	
Stop.	
All up one hundred.	
Go on.	

4. Oblique target, range to right end 1,550 yards, range to left end, 1,400 yards, both by range-finder.
  Angle of sight to right end plus 20′, and to left end minus 10′.
  Target width 3° 10′.
  Wind 30 m.p.h. at 9 o'c.
  D.A.P. and post method. No. 1 Gun—Pivot gun.

Fire controller.	N.C.O. i/c gun position.
	Zero lines.
	All—Left eight seven degrees two owe minutes.
	Reports '' Guns on zero lines.''
No. 1—Fifteen fifty plus two owe minutes.	
No. 2—Fifteen hundred plus one owe minutes.	
No. 3—Fourteen fifty nil.	
No. 4—Fourteen hundred minus one owe minutes.	
	Reports '' Guns ready to load.''
Load.	
Distribution.	
No. 1—Nil.	
No. 2—Left three owe minutes.	
No. 3—Left—One degree.	
No. 4—Left—One degree three owe minutes.	
Right and Left two taps.	
Wind—Left—One degree.	
Fire.	
Stop.	
All down fifty.	
Go on.	
Stop.	
All up one hundred.	
Go on.	

5. Oblique target.
  Range to right end 1,450, to left end 1,350, both by range-finder.
  Angle of sight to right end plus 40′ and to left end plus 10′.
  Angular width 1° 30′ (less than gun frontage).
  Wind—Nil.
  Director method.

Fire controller.

Zero lines.

No. 1—Right—One six eight degrees two owe minutes.

No. 2—Right—One seven five degrees three owe minutes.

No. 3—Left—One seven seven degrees.

No. 4—Left—One seven owe degrees one owe minutes.

No. 1—Fourteen fifty plus four owe minutes.

No. 2—Fourteen hundred plus three owe minutes.

No. 3—Fourteen hundred plus two owe minutes.

No. 4—Thirteen fifty plus one owe minutes.

Load.

Right and Left—One tap.

Rapid fire.

NOTE.—An alternative method of working out the elevation is as follows :—

Elevation.

No. 1—Two degrees three five minutes.

No. 2—Two degrees two owe minutes.

No. 3—Two degrees five minutes.

No. 4—One degree five owe minutes.

6. Area target.

Range to near end 1,650 yards, to far end 1,750 yards, both by range-finder.

Angle of sight to near end plus 13′ and to far end plus 21′.

Angular width of target 4°.

Wind Nil.

Director method.

N.C.O. i/c gun position.

Reports " Guns ready to load."

Fire controller.

Zero lines.

No. 1—Right—one nine degrees two owe minutes.

No. 2—Right—Seven degrees three owe minutes.

No. 3—Left—Seven degrees.

No. 4—Left—One eight degrees two owe minutes.

Elevation—All two degrees four five minutes.

Load.

Distribution.

No. 1—Nil.

No. 2—Left—Five owe minutes.

No. 3—Left—One degree four owe minutes.

No. 4—Left—Two degrees three owe minutes.

Right and Left three taps.

Fire.

Stop.

All down one owe minutes.

Go on.

Stop.

All up two owe minutes.

Go on.

Stop.

All down three owe minutes.

Go on.

Stop.

All up four owe minutes.

Go on.

Or

Elevation—All two degrees two five minutes.

Load.

Distribution.

No. 1 Nil.

No. 2—Left—Five owe minutes.

No. 3—Left—one degree four owe minutes.

N.C.O. i/c gun position.

Reports " Guns ready to load."

No. 4—Left—two degrees
  three owe minutes.
Right and Left three taps.
Fire.
Stop.
All up one five minutes.
Go on.
Stop.
All up one five minutes.
Go on.
Stop.
All up one five minutes.
Go on.

SECTION 31.—FLANKING AND OVERHEAD FIRE

1. The provision of supporting fire to our own troops is the main tactical role of the machine gun. The safety of the troops to whom such support is being given must be the first consideration of the machine gun commander.

2. Supporting fire can be provided either from the flank of a line of advance or defended locality or by overhead fire, that is, when the trajectory passes over the heads of our own troops. Where possible, flanking fire positions should be sought, not only because of the greater fire effect generally obtained from the beaten zone in enfilade, but also because fire from a flank can be put down with safety considerably closer to the troops being supported than can overhead fire. Before the occupation of a position for the purpose of overhead fire it is necessary to determine that such fire will be safe to our own troops. This increases the time required for the guns to be brought into action.

3. In order that the safety of the troops may be ensured, it is essential that their position or movements should be observed by or known to the fire controller.

In defence, this should not present any serious difficulty. In attack, the possibility of observing the movements of our own troops will depend on various factors, e.g., the nature of the ground (whether open, close, flat or hilly), obstructions to the field of view, bad visibility, smoke screen, etc. Since such observations can hardly be assured, it is evident that considerable caution will have to be exercised.

4. Apart from the above considerations, the machine gun, by reason of its stable mounting and the close grouping of its fire, is well suited to carry out flanking and overhead fire with safety to our own troops.

5. Flanking and overhead fire are governed by definite rules, which are contained in the following sections.

These rules take into account unarmoured troops in the open. If our own troops are dug in, common sense will indicate to what extent the rules may be relaxed. For instance, it may be safe to fire just over the top of deep trench 200 yards in front of the gun, but at longer ranges, the risk of dropping bullets at a steep angle of descent into our own trenches must not be taken.

Tanks are immune from machine gun fire, and fire may be put down close ahead of, or even among, friendly tanks.

6. In solving any problem in connection with the safety of our own troops, the worst possible case must be taken as a basis for applying the rule.

LESSON 126.—FLANKING FIRE

Stores :—
  Sand model, slide rule, and field glasses.

Method of instruction :—
  The application of the rules will be explained on the model and the class will then practise on the ground.

1. Explain the following are the rules for flanking fire :—
The diagrams referred to in Plate 28 illustrate examples in defence and attack.

i. The line of fire must not be closer than 3° to the line joining the gun and the flank of our own troops.

Defence, A represents the flank of our own troops and GB the line of fire. For safety, the angle AGB must be 3° or greater.

Attack, GB is the line of fire to engage a target. If our riflemen are advancing in the direction shown, as soon as any man reaches the line GC, fire must cease.

ii. The 3° limit extends to a point 300 yards beyond the place where the top bullet of the gun on the highest elevation is expected to fall.

iii. This type of fire must not be attempted if the position of our own troops in the vicinity of the danger area is unknown.

As already pointed out, this entails either observation of our own troops or a timed programme, based on a rate of advance which must not be exceeded by the infantry companies concerned.

iv. Arrangements must be made to prevent tapping inside the 3° limit.

v. Careful allowance must be made for side winds. For example, if in Defence, a wind was blowing from the left requiring an allowance of L 40′, it would be necessary to place B 40 minutes to the left of its present position, or, in other words, increase the safety allowance to 3° 40′.

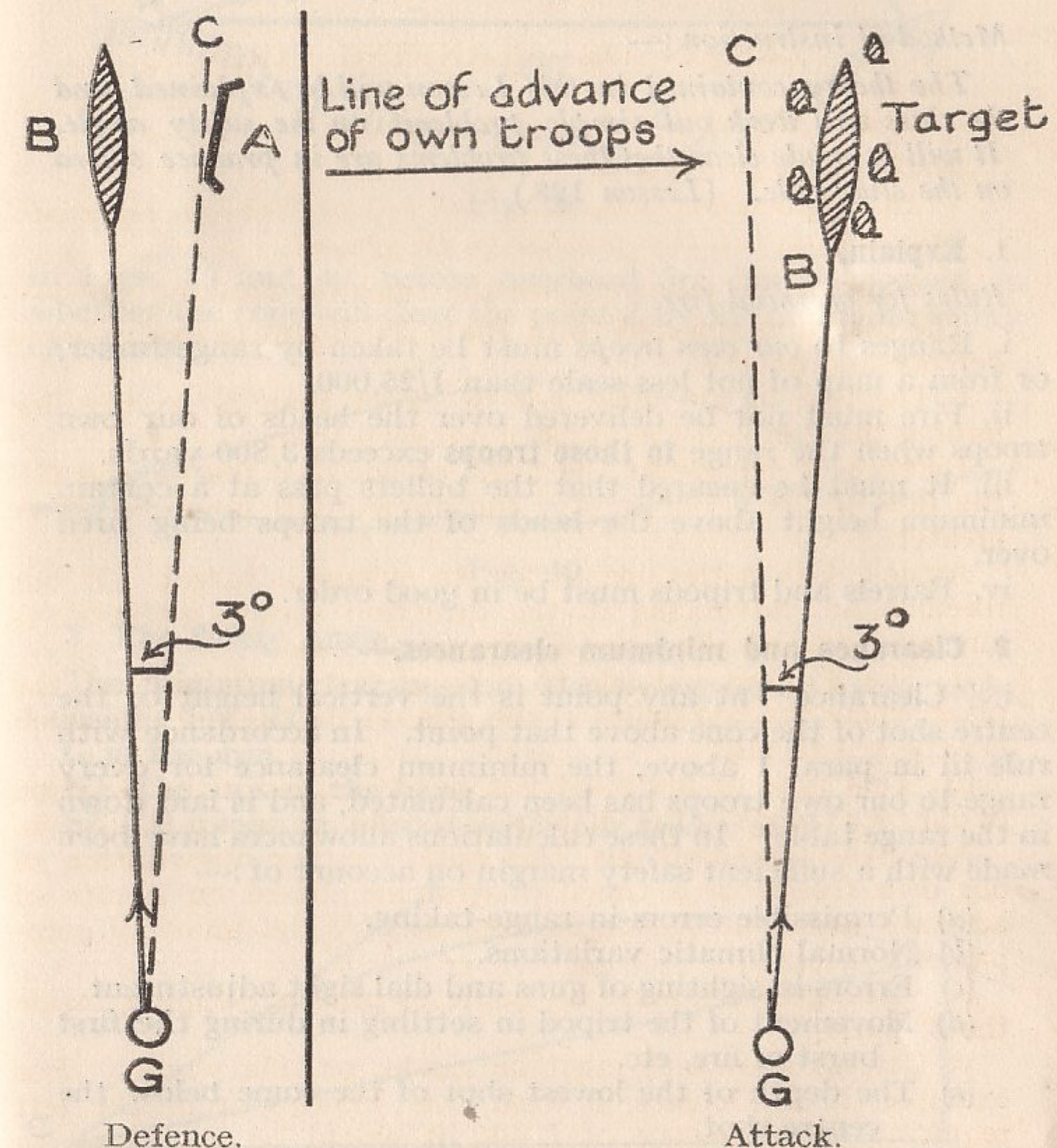2. The lateral allowance of 3° covers :—

i. Minor inaccuracies in aiming, tapping, and in estimation of the strength of side winds.

ii. Movement of the tripod settling in during the first burst of fire, etc.

iii. Half the width of the beaten zone.

FLANKING FIRE.

Defence.   Attack.

A is a rifle locality.   B is the target.
B is a fixed line to it.   G is the gun line.
G is the gun line.

LESSON 127—OVERHEAD FIRE (THEORY)

Instructor's Notes

Stores :—

Blackboard, slide rule, range table and field glasses.

Method of instruction :—

The theory contained in this Lesson will be explained and the class will work out simple problems on the safety angle. It will be made clear that these problems are in practice solved on the slide rule. (Lesson 128.)

1. Explain.—

Rules for overhead fire.

i. Ranges to *our own troops* must be taken by range-finder, or from a map of not less scale than 1/25,000.

ii. Fire must not be delivered over the heads of our own troops when the range **to those troops** exceeds 3,800 yards.

iii. It must be ensured that the bullets pass at a certain minimum height above the heads of the troops being fired over.

iv. Barrels and tripods must be in good order.

2. Clearance and minimum clearances.—

i. " Clearance " at any point is the vertical height of the centre shot of the cone above that point. In accordance with rule iii in para. 1 above, the minimum clearance for every range to our own troops has been calculated, and is laid down in the range table. In these calculations allowances have been made with a sufficient safety margin on account of :—

(a) Permissible errors in range-taking.
(b) Normal climatic variations.
(c) Errors in sighting of guns and dial sight adjustment.
(d) Movement of the tripod in settling in during the first burst of fire, etc.
(e) The depth of the lowest shot of the come below the centre shot.

ii. Influence of ground.

In Fig. 39, the cone at C is clearing troops at Z owing to two distinct factors :—

(a) The natural curve of the trajectory above its line of sight.
(b) The fact that the troops at Z are below the line of sight to the target.

In Fig. 40, the cone at C is clearing troops at Z on account of the curve of the trajectory only. The problem to be solved
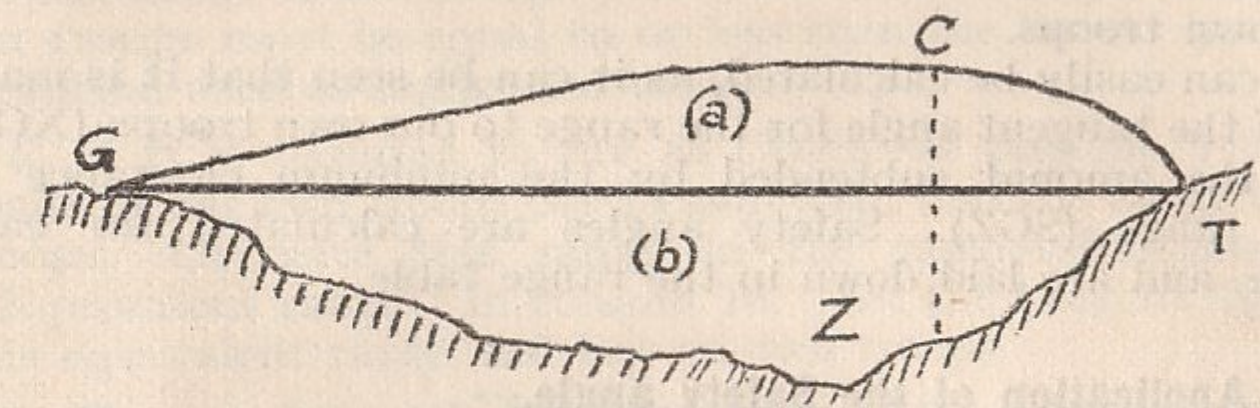

Fig. 39.

in Figs. 39 and 40, before overhead fire can be opened, is whether the cone will clear the point Z by the minimum safety clearance.
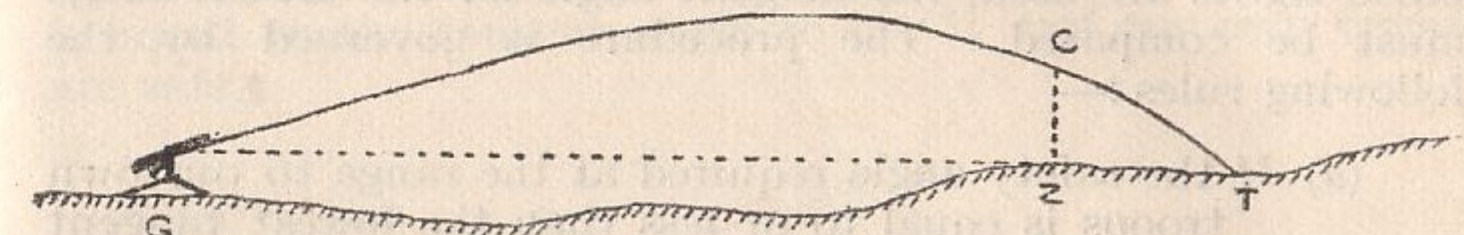

Fig. 40.

3. The Safety Angle.—

The minimum clearance can also be expressed as an angle. Consider Fig. 41.

G is the gun.

GX the axis of the bore.
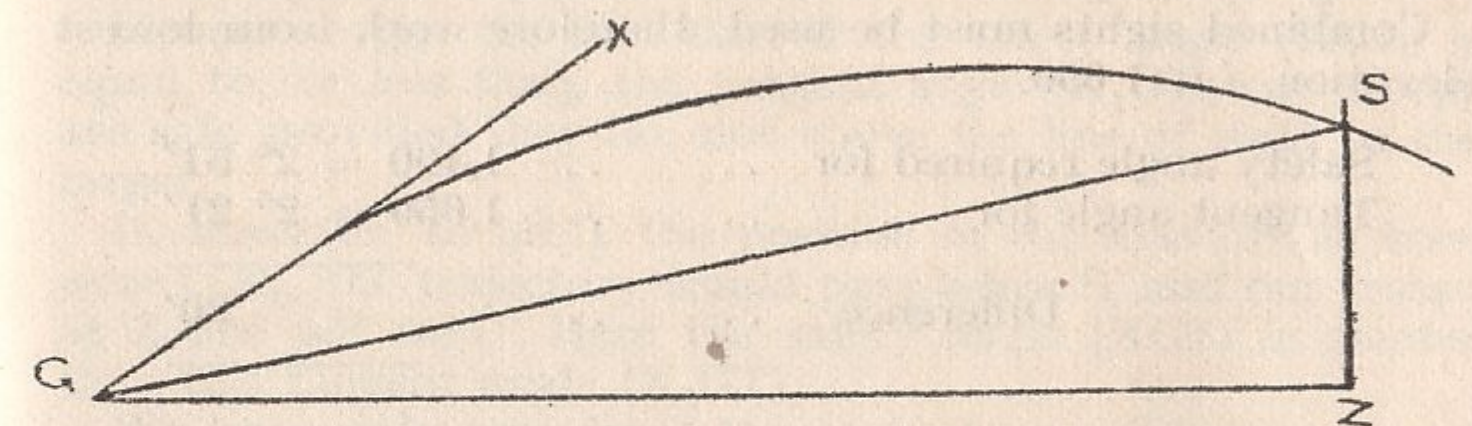
SZ the minimum clearance for our troops at Z.

Fig. 41.

Theoretically, there is only one position of the axis of the bore which will cause the centre shot to pass exactly through S. Suppose GX to be this position ; any lower position would cause the trajectory to pass below S, and the necessary minimum clearance would not be given.

The angle XGZ is known as the safety angle for the range GZ, and is defined as the minimum angle which must be included between the axis of the bore and the line of sight to our own troops.

It can easily be calculated, as it can be seen that it is made up of the tangent angle for the range to our own troops (XGS) and the amount subtended by the minimum clearance at that range (SGZ). Safety angles are calculated for each range, and are laid down in the range table.

4. Application of the Safety angle.—

In order to decide whether our troops in a particular position are safe when a target is to be engaged, it is necessary to compare the safety angle for the range to our own troops with the tangent angle for the range to the target. If combined sights are used, the tangent angle for the lowest range must be compared. The procedure is governed by the following rules :—

(a) If the safety angle required at the range to our own troops is equal to or less than the lowest tangent angle to be employed, our troops are safe.

(b) If the safety angle required is greater than the tangent angle, our troops are not safe unless they are below the line of sight to the target to the extent of the difference between these two angles.

Example :—

Range by range-finder to target, 1,700 yards.
Range by range-finder to our own troops, 1,400 yards.
Combined sights must be used, therefore work from lowest elevation, i.e. 1,650.

Safety angle required for	..	..	1,400 = 2° 51′
Tangent angle for	..	..	1,650 = 2° 21′
Difference	..	..	= 30′

Therefore our troops must be 30′ below the line of sight to the target to be safe.

The angle which our troops must be below the line of sight to the target to be safe can be measured from the gun position by means of the graticules in field-glasses, by any other accurate method of measuring vertical angles, or by the slide rule.

In indirect fire, for our troops to be safe, the safety angle for the range to our troops plus or minus the angle of sight to our troops must be equal to or less than the lowest quadrant elevation used to engage the target.

5. If it is required to fire as closely as possible over the heads of our own troops (see Lesson 130), find the range to our troops. Opposite this range in the range-table find the " Equivalent range " in column 16. Set the tangent sight to this equivalent range and lay on own troops.

6. Theory of the rule for comparison of the safety angle with the tangent angle.—

In Fig. 42, G is the gun, Z our own troops, SZ the minimum clearance for the range GZ and T is the target.

Now if to hit T the axis of the bore were in a position GX and the centre shot passes through S, XGZ, the safety angle, is equal to the tangent angle to hit T, and our own troops are safe.
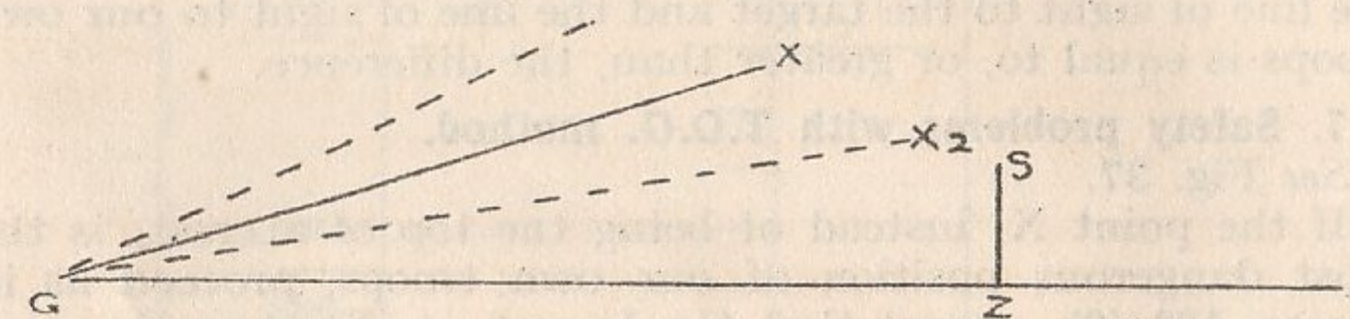

Fig. 42.

If to hit T the position of the axis of the bore were in a position GX₁, the trajectory of the centre shot would pass above S and our troops are safe.

Hence we get the rule that if the safety angle (XGZ) is equal to, or less than, the tangent angle (X₁GT) our troops are safe provided they are not above the line of sight to the target.

If, however, to hit T the position of the axis of the bore were GX₂, the trajectory would pass below S, and our troops at Z are not safe. Here the safety angle (XGZ) is greater than the tangent angle (X₂GT).

We have only considered the case where our troops are on the line of sight to the target. The ground will often be favourable, and our troops (Z) may be below the line GT.

In Fig. 43, the ground is favourable, and our troops, instead of being at Z are at Z₁ ; we can therefore lower the axis of the bore from GX to GX₁, where X₁GZ₁ is the safety angle for the range GZ₁, or (GZ) and X₁GT is the tangent angle to hit T.

Here it can be seen that the safety angle X₁GZ₁ is greater than the tangent angle (X₁GT) by the amount the ground

has given us (ZGZ₁) and our troops are safe. The ground must give us this amount, or our troops would be unsafe.

Hence we get the rule that if the safety angle for the range to our own troops is greater than the lowest tangent angle used
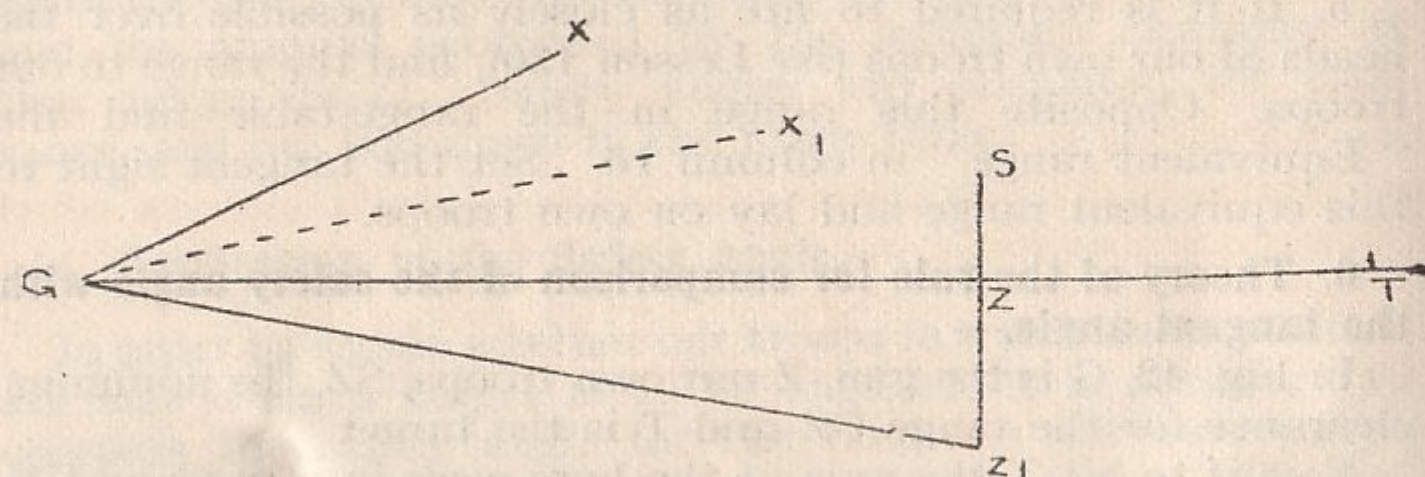

Fig. 43.

to engage the target ; our troops will be safe if the angle between the line of sight to the target and the line of sight to our own troops is equal to, or greater than, the difference.

7. Safety problems with T.O.G. method.

See Fig. 37.

If the point X, instead of being the top of a crest, is the most dangerous position of our own troops, proceed as in Lesson 123 (2), except that the lowest quadrant angle used to engage T₁—T₂ will be compared with the safety angle for the range G₁X instead of the minimum Q.A. to clear X.

LESSON 128.—USE OF THE SLIDE RULE IN OVERHEAD FIRE

Instructor's Notes

Stores :—
Slide rules and field glasses.
Method of instruction :—
The various methods of applying the slide rule will be explained indoors and the class will then practise on the ground. The instructor setting practical problems.

1. Explain.—The purpose of the slide rule.

In order to save the labour entailed in comparing the tangent angles and safety angles, the Machine-Gunner's Slide Rule is provided. (Lesson 40.)

To use the slide rule in the case mentioned in the sample in Lesson 127 4, (b) set 1,400 yards on the " Range to Own Troops," scale against 1,650 yards on the " Range to Target " scale. This will cause the slide to project above the top of the rule.

Hold the rule vertically at the full length of the string, bringing the shoulders at the top of the rule Y, in Fig. 44, along the line of our own troops nearest the target.

If the target can be seen above the top of the slide X our troops are safe.

In effect, the height XY subtends at 24 inches from the eye, the amount our troops must be below the line of sight to the target to be safe.

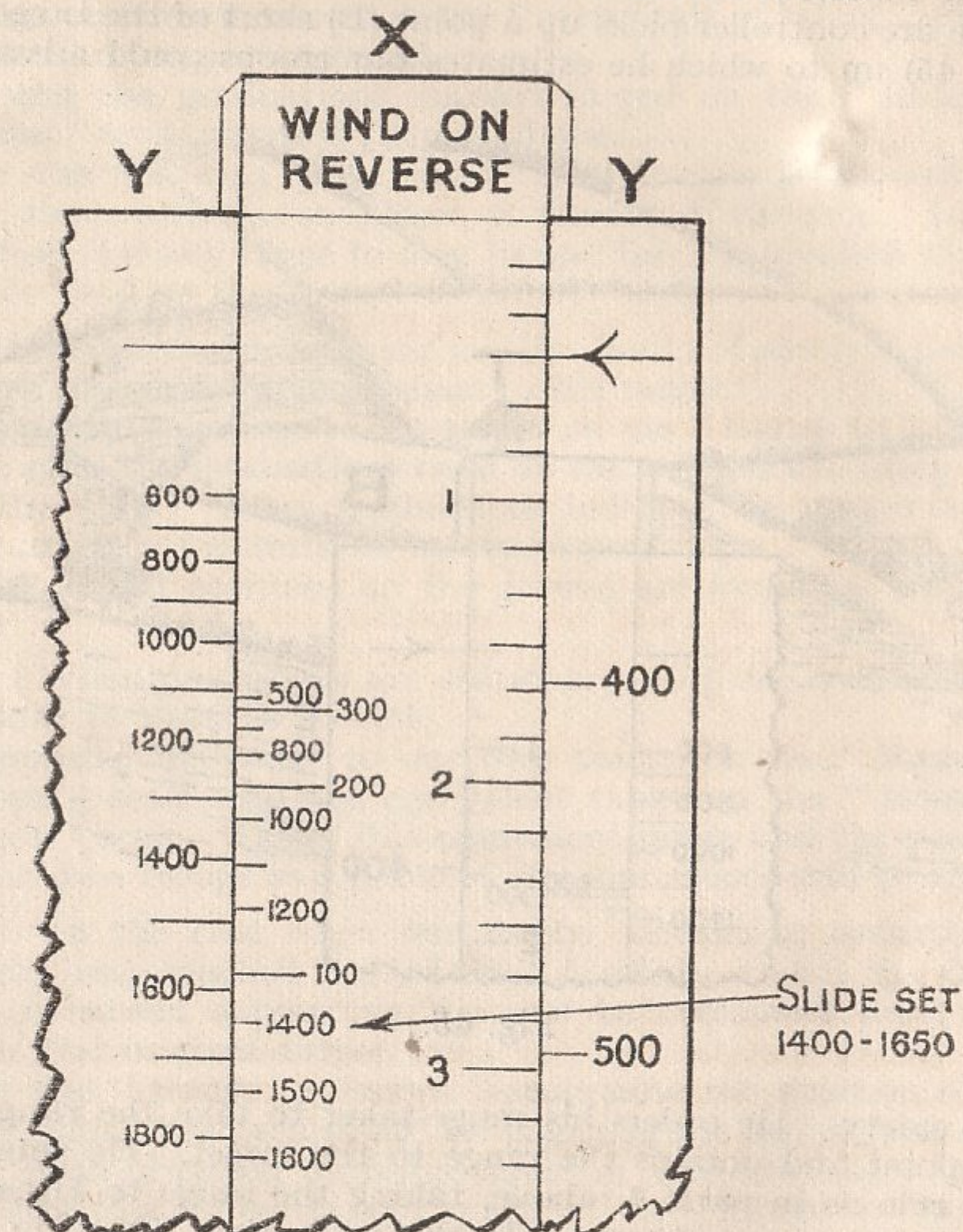On the right side of the rule will be found a scale on which this amount is indicated when the slide rule is set.

Fig. 44.

2. The practical use of the slide rule.

The slide rule is employed in the following cases :—

i. In the reconnaissance for a position from which to engage

a definite target over the heads of our troops who are stationary, to determine whether fire can be opened with safety.

The slide rule is set and used as above.

ii. To determine how near to a target our advancing troops can be supported by overhead fire with safety.

The nearest position of our troops to the target is known as the " far limit of safety " for that particular target.

The problem is solved by trial and error, using the slide rule as follows :—

The fire controller picks up a point (B) short of the target T (Fig. 45) up to which he estimates our troops could advance
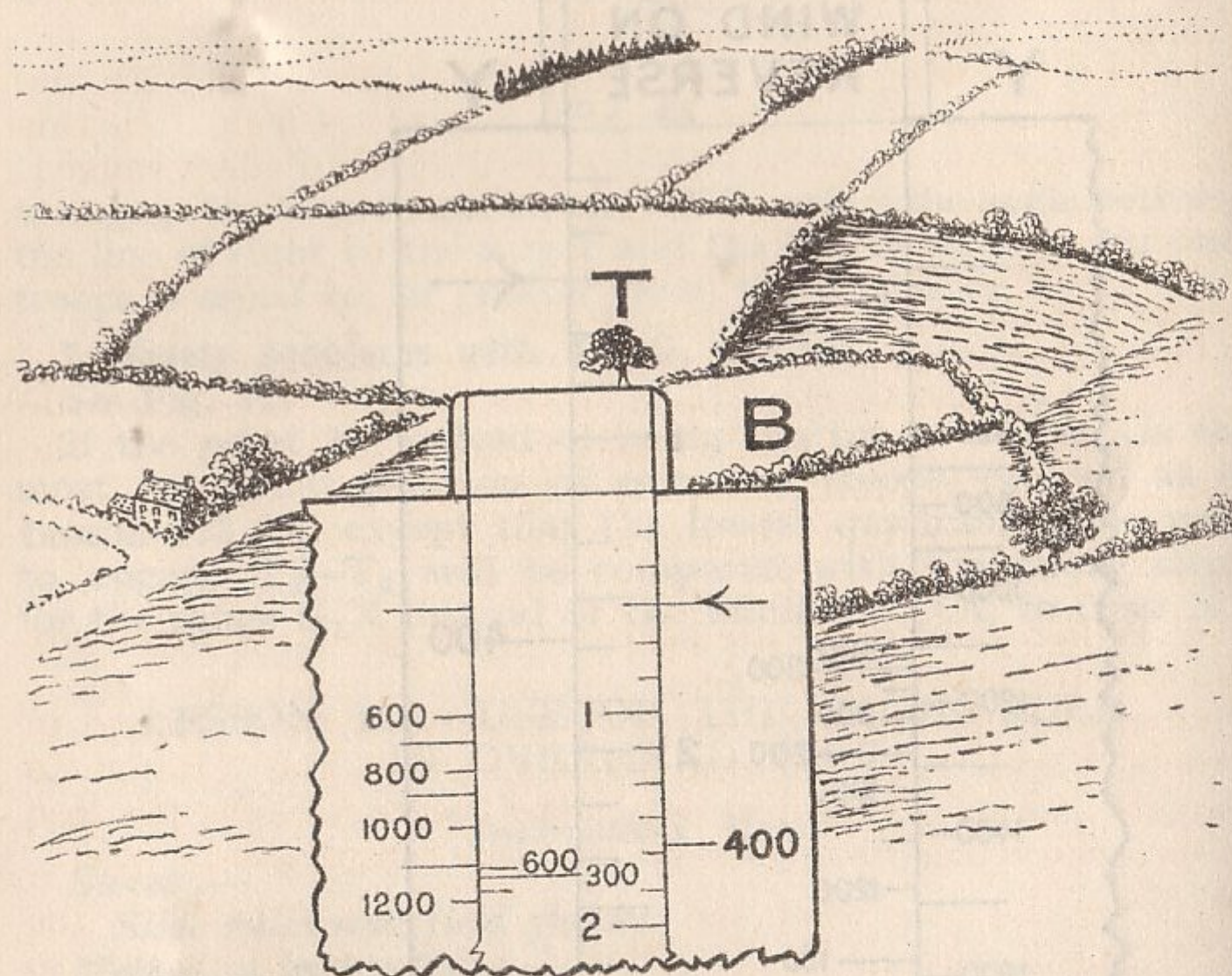

Fig. 45.

with safety. He orders his range-taker to take the range to this point and obtains the range to the target. He sets the slide rule as in para. 1, above, taking the range to B as the range to our own troops. If the projection XY (Fig. 44) does not fit in between the lines of sight to B and T, our fire must cease at some point nearer the gun than B. If it fits in with some amount to spare, then fire can be continued until our troops reach some point closer to T.

Another point is then selected for trial either nearer or

farther away from B, and the procedure repeated until the far limit of safety is found by a process of elimination.

iii. to determine, when our troops are withdrawing, the line they must clear before fire can be opened on the ground evacuated by them.

Work out the far limit of safety as in ii, above, taking the ground on which fire is eventually required as the target.

iv. To determine, in the case of our troops advancing along the line of fire through the gun position, what line they must clear before fire can be opened.

This position is known as the " near limit of safety " for the particular target concerned.

Using the graduations marked in red on the " Range to Troops " scale, proceed as in ii, above.

In the following three cases the slide rule is set with the slide flush with the shoulders at the top of the rule. In this position for any range to own troops, the " equivalent range " can be read on the " range to target " scale.

v. To determine the near and far limits of safety when our troops are on the line of sight to the target.

Opposite the range to the target on the " Range to Target " scale read the graduations both on the red and the black scale on the slide. These graduations indicate the ranges to the near and the far limits of safety respectively.

The actual positions on the ground are found by trial and error.

vi: When our troops are stationary, to place overhead fire as close to them as possible.

Opposite the range to our own troops on the " Range to Troops " scale read the equivalent range on the " Range to Target " scale. Using this equivalent range and the position of our own troops as a point of aim, our troops will be safe.

vii. In the case when our troops, advancing towards the target, have reached the far limit of safety, to lift the fire so that overhead supporting fire can be continued until they reach the original target.

On the " Range to Troops " scale note the position of the range which has been in use for engaging the target (this must have been obtained by range-finder or 1/25,000 map). Read opposite this the equivalent range on the " Range to Target " scale. Using this equivalent range on the sight and the target as a point of aim, our troops will be safe when they reach the position of the target.

LESSON 129.—USE OF AN O.P. IN OVERHEAD FIRE

Instructor's Notes

Stores and method of instruction as in Lesson 128.

1. Explain.—

i. If our troops and the target cannot be seen from the gun position, *e.g.* in indirect fire, the rules for the use of the slide rule must be modified unless an observation post can be found which fulfils the following conditions :—

    (*a*) It must not be higher than the gun position by more than six feet.

    (*b*) The target, the gun position and the movements of our own troops along the line of fire in the vicinity of the danger area must be visible.

    (*c*) The ranges observation post-target and gun-target must be within 50 yards.

ii. The use of an observation post which is not within six feet in height of the gun position in practice presents a complication, and every effort must be made to avoid it by the careful siting of guns and observation post in relation to each other.
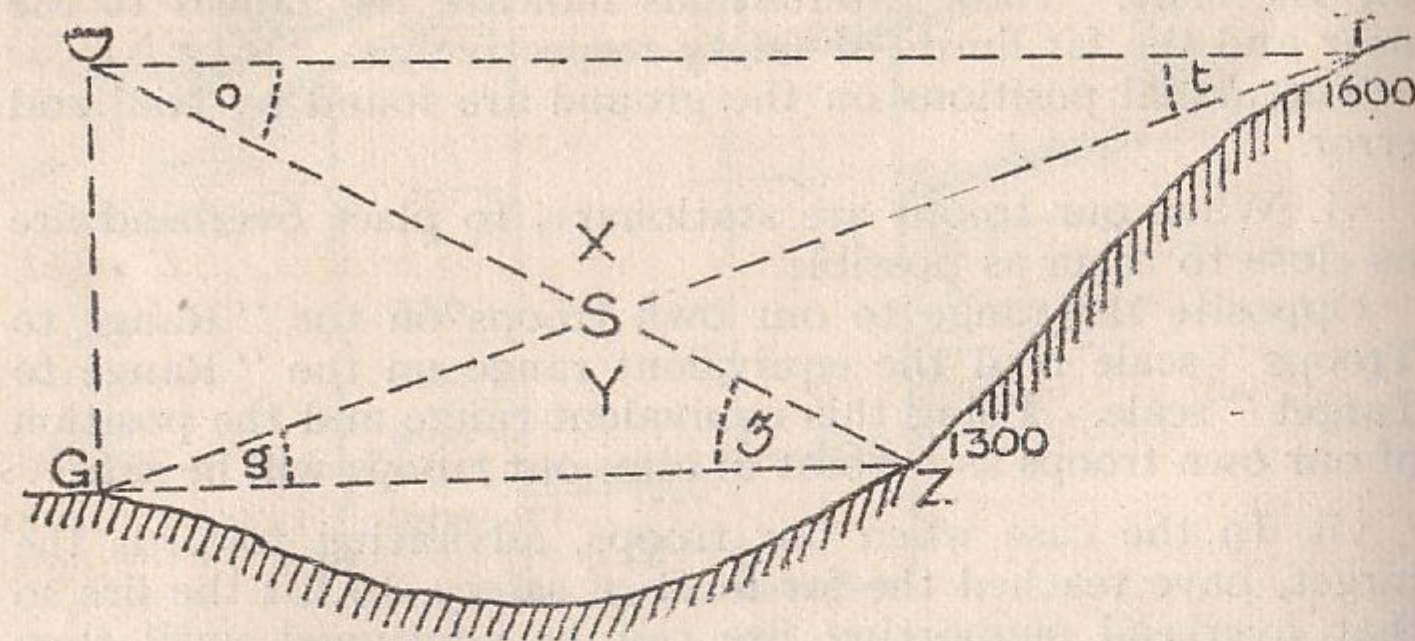

Fig. 46.

When this is unavoidable, the following will be the procedure, which only holds good if the conditions in para. i, (*b*) and (*c*) above, are fulfilled :—

    (*a*) Find the angle subtended by the difference in height between the observation post and the guns at the range to our troops. Subtract from it the angle subtended by this height at the range to the target.

    (*b*) Set the slide rule in the ordinary way. Using the scale on the right side, increase the amount projecting by the difference obtained in (*a*), above. Now use the rule in the ordinary way.

iii. Theory.

The sum of the angles of any triangle $=180°$. Therefore angles $o+T \times X = g+z+Y$.

Angle $X =$ angle Y.

Therefore $o = g+z-T$.

Angle g $=$ normal setting on slide rule.

Angles t and Z can be found by converting the vertical interval GO to an angle, at the ranges G — T and G — Z respectively.

If the height of the observation post above the guns were 10 yards.

Then by V.I. table $t=21'$ and $z=26'$.

Difference $5'$.

This is the amount by which the projecting portion of the slide rule has to be increased before using the slide rule.

LESSON 130.—LAYING A FIXED LINE (FLANKING FIRE) AS NEAR AS IS SAFE TO A DEFENDED LOCALITY

Instructor's Note

Stores :—

    Gun, tripod, belt, belt box, dummy cartridges, dial sight, aiming post.

Explain and demonstrate.—

i. Calculate the safety allowance required, *e.g.* 3 degrees plus any necessary addition for side wind. This addition must be frequently checked to keep up to date with changes in the strength and direction of the wind.

ii. Set this angle on the deflection drum and, using the collimator, lay on the defended locality.

iii. By elevating or depressing the gun, pick up the limit of flanking safety.

iv. Select a point either on, or outside this line, in the area where the platoon commander has ordered the fixed line to fall.

v. Obtain the range to this point. Decide on the elevation to be given to each gun so that the fixed line shall be as long as possible without there being gaps between the beaten zones.

vi. When this has been done, lay the gun on the selected point with the necessary range on the tangent sight.

vii. Reset the deflection drum, and dial on the tripod at zero.

The gun is now laid on its fixed line.

viii. Record the elevation now on the gun, by means of the dial sight.

ix. Put out the aiming post and align the collimator on it.

x. Half load and press the thumbpiece.

NOTE.—Neither gun will tap right nor left.

LESSON 131.—LAYING A FIXED LINE (OVERHEAD FIRE) AS NEAR AS IS SAFE TO A DEFENDED LOCALITY ; EACH GUN COVERING 50 YARDS OF FRONT

Instructor's Notes

Stores :—

As for Lesson 130, *and in addition, slide rule and range table.*

Explain and demonstrate.—

i. Obtain the range by range-finder to the defended locality.

ii. From the slide rule or range table ascertain the minimum range which will ensure the safety of the troops in the defended locality (*i.e.* the equivalent range).

iii. Convert 25 yards to an angle at the latter range.

iv. Set this angle on the deflection drum of No. 1 gun—Right. No. 2 gun—Left.

v. Lay both guns by means of the collimator on the centre of the defended locality.

Reset the deflection drums and dial on the tripod at zero.

vi. Set the range obtained in (ii) above, on the tangent sight of both guns.

vii. Relay both guns on the defended locality.

viii. Record the elevation on the guns by means of the dial sight.

ix. Put out the aiming post and align the collimators on it.

x. Half load and press the thumbpiece.

xi. Determine the number of taps required for each gun to cover 25 yards right and left at the range obtained in (ii), above.

NOTE.—No lifts will be given.

It may be necessary to consider also flanking safety for one or more defended localities.

LESSON 132.—LAYING A FIXED LINE WHEN NO RECONNAISSANCE BY DAY HAS BEEN CARRIED OUT

Instructor's Notes

Stores :—

As for Lesson 131, *and in addition, torches, aiming lamp.*

Explain and demonstrate.—

i. A light will be shown in the direction of the guns from a position on which the fixed line is to fall (*see* Lesson 92).

This position must be chosen with due regard to safety.

ii. (*a*) Obtain the range by range-finder to the light.

(*b*) Lay the gun using the tangent sight set at this range on the light. It may be necessary to assist with a torch.

(*c*) Set the range on the range drum of the dial sight and level the bubble by means of the angle of sight drum.

(*d*) Set up the night aiming lamp and align the collimator on it.

(*e*) Half load and press the thumbpiece as soon as the individual showing the light has cleared the line of fire.

LESSON 133.—SAFETY CALCULATED FROM THE MAP

Instructor's Notes

Stores :—

Maps (1/25,000 or larger scale), *protractors, range table.*

Method of instruction :—

The instructor will set problems involving both flanking and overhead fire, as explained below.

Explain.—

i. Plot on the map the gun position, the position of our own troops and the target.

ii. Ascertain from the contours the highest point over which there is a possibility of fire being directed. Subtract from this height the height of the gun position ; this gives the height of the crest on which the troops are above the gun position.

iii. Add to this height the minimum clearance required for the range to our troops. From the Q.A. graph determine whether the trajectory curve for the Q.A. for the target clears this height at the range to our troops.

Example :—

	Range	Contour level
Gun position	—	105 metres.
Target	2,500 yards.	120 ,,
Own troops	1,000 ,,	145 ,,

Target is 15 metres above the gun, therefore Q.A. required is 5°. (Taken from Q.A. graph, using a range of 2,400.) Our troops are 40 metres above the gun.

The minimum clearance is 17 metres (from Q.A. graph, at bottom) at 1,000 yards.

Therefore total clearance required 57 metres.

The 5° curve gives a clearance of 63 metres at 1,000 yards, therefore our troops are safe.

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